AMENDMENT TO THE NAVAL PETROLEUM RESERVES PRODUCTION ACT OF 1976

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY AND MINERAL RESOURCES

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

NINETY-SEVENTH CONGRESS

SECOND SESSION

ON

S. 2063

A BILL TO AMEND THE NAVAL PETROLEUM RESERVES PRODUCTION ACT OF 1976 TO AUTHORIZE THE SECRETARY OF THE INTERIOR TO PERMIT LOCAL ENTITIES TO EXTRACT AND USE COAL FROM LANDS WITHIN THE NATIONAL PETROLEUM RESERVE IN ALASKA FOR HEAT AND GENERATION OF ELECTRICITY

FAIRBANKS, ALASKA, APRIL 8, 1982

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CONTENTS

Page

S. 2063 5

STATEMENTS

Anderson, Ralph, special assistant to the mayor, North Slope Borough, Barrow, Alaska 11

Brower, Eugene, mayor, North Slope Borough, Alaska 14

Deisher, Phil, Fairbanks special assistant to Governor Jay Hammond, State of Alaska; accompanied by Gil Eakins and Roy Merritt 10

Johnson, Leland A., P.E. president, Arctic Slope Technical Services, Inc., Anchorage, Alaska 24

Kagak, Jacob, mayor, Wainwright, Alaska 20

McVee, Curtus V., State Director, Alaska, Bureau of Land Management, Department of the Interior 7

Murkowski, Hon. Frank H., a U.S. Senator from the State of Alaska 1

Triplehorn, Dr. Don M., professor, Geclogy/Geophysics Department, University of Alaska, Fairbanks, Alaska 47

APPENDIX

Additional material submitted for the record 140

AMENDMENT TO THE NAVAL PETROLEUM RESERVES PRODUCTION ACT OF 1976

THURSDAY, APRIL 8, 1982

U.S. SENATE,
SUBCOMMITTEE ON ENERGY AND MINERAL RESOURCES,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Fairbanks, Alaska.

The subcommittee met, pursuant to notice, at 9:30 a.m., in room 314, Federal Building, Fairbanks, Alaska, Hon. Frank H. Murkowski, presiding.

Present: Senator Murkowski.

Also present: Roger Sindelar, counsel; and Joyce Bamberger, staff assistant to Senator Murkowski.

OPENING STATEMENT OF HON. FRANK H. MURKOWSKI, A U.S. SENATOR FROM THE STATE OF ALASKA

Senator MURKOWSKI. I'd like to welcome you this morning to the U.S. Senate Committee on Energy and Natural Resources, the Subcommittee on Energy and Mineral Resources. Senator John Warner is the chairman of that subcommittee. I have with me on my right Mr. Roger Sindelar, counsel to the Subcommittee on Energy and Mineral Resources, and Ms. Joyce Bamberger on my left, who handles this particular area on my staff.

Gentlemen, on behalf of Senator Warner, the chairman of the subcommittee, I am certainly pleased to be here today to Chair these field hearings on S. 2063, a bill to amend the Naval Petroleum Reserve Production Act of 1976. Also, I might add that Senator Stevens regrets that he cannot be here. He left Fairbanks early this morning to fly up to the Canadian Beaufort Sea, and to go out on one of the ice island drilling platforms, and he asked me to be sure and indicate his interest in this bill and proposed legislation, and also asked me to say "Hello" to all of you.

This bill would authorize the Secretary of the Interior to permit local entities to extract and use coal from lands within the National Petroleum Reserve in Alaska for heat, power generation of electricity, and so forth.

I also want to thank all of you for attending and participating in this hearing on this needed and worthwhile legislation. And I think that a number of you that are in attendance speaks for itself. This legislation, I might add, was initiated in response to a letter from the mayor of the North Slope Borough advising me that the Native villages of the North Slope of Alaska are greatly in need of finding energy sources other than fuel oil to generate electricity and to provide heat for homes, schools, and small businesses in their communities. Presently, these areas must rely on fuel oils as a source of energy, which despite the proximity of gas and oil reserves, the costs of transferring oil through the pipeline, and then shipping to refineries, and then flying back again, or bringing in barges to the Slope results in families in the North Slope paying a significant amount of their income for monthly heat or power generation. Clearly, exploring the feasibility of using nearby and abundant coal reserves as an alternate, more economically provides a badly needed energy source. I might also indicate that this pilot plant could potentially lead the way for some coal development in the Arctic by utilizing new technical capabilities, such as the coal slurry concept and the feasibility of bringing the coal on the bottom of the coast and bringing it up on a pipe to a ship that would be out in adequate water and bring the coal aboard in a slurry form. That would eliminate the difficult associations of port development in the Arctic.

So, all this really amounts to, and I'm not suggesting this bill would include anything like that, I'm simply pointing out that this would allow the first—in current years—commercial production of coal in the Arctic, designed strictly for this community of Wainwright and any adjacent areas for this specific purpose.

Present law and regulations do not allow commercial feasible extraction of coal for use as a home fuel. It is my hope with the passage of this legislation that the Secretary of the Interior will issue permits to entities within the North Slope Borough to allow them to extract coal for use in small scale coal fired projects.

Originally, I understand, it was contemplated to be constructed in the village of Wainwright to enable the coal to be used for space heating in homes, et cetera.

The feasibility study prepared by the North Slope Borough indicates that approximately 3,000 tons of coal per year will be needed for this plant in Wainwright. Identified coal reserves within NPRA are estimated at 44 billion tons. The coal reserve for this project is located about one-half mile from the village of Wainwright. The cost of extracting this coal has been estimated at approximately a hundred dollars per ton, and original project projections indicate that this model demonstration plant could cost approximately $10½ billion—excuse me—$10½ million. I've been in Washington too long!

Exploring the use of coal as an alternative energy source will become more valuable as our Nation's dependence on foreign oil continues. Although the price of oil recently has stayed relatively stable, the instability of the relationships of the OPEC countries, among themselves and within our economy, should encourage us to continue to explore the feasibility of developing alternative economic energy resources.

I strongly endorse the passage of this legislation, not only because it will serve the local needs of the North Slope people, but because through its development as a demonstration project as recommended by the National Academy of Sciences, which I am pleased to inform you has a coal plant near Wainwright, other communities in Alaska, such as Kotzebue, and nationwide, may also benefit. I want to thank you, and again express my thanks to Senator Warner for allowing these hearings to be held in Fairbanks today.

We would proceed with the list of witnesses, and we're pleased to have our first witness, Mr. Curt McVee, Alaska State Director of the Bureau of Land Mangement, the U.S. Department of the Interior. I would request that you come before the witness table. And we certainly look forward to your testimony, Curt, and wish you a very good morning.

[The statement of Senator Murkowski upon introducing the bill and the text of S. 2063 follows:]

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PROCEEDINGS AND DEBATES OF THE 97th CONGRESS, SECOND SESSION

Vol. 128 WASHINGTON, THURSDAY, FEBRUARY 4, 1982 *No. 8*

Senate

By Mr. MURKOWSKI (for himself and Mr. STEVENS):

S. 2063. A bill to amend the Naval Petroleum Reserves Production Act of 1976 to authorize the Secretary of the Interior to permit local entities to extract and use coal from lands within the National Petroleum Reserve in Alaska for heat and generation of electricity; to the Committee on Energy and Natural Resources.

NORTH SLOPE COAL

● Mr. MURKOWSKI. Mr. President, I am today introducing legislation to grant to the Secretary of the Interior the authority to permit local governmental entities on the North Slope of Alaska to extract coal from the National Petroleum Reserve in Alaska ("NPR-A") to use as a fuel within the North Slope area for heating or for the generation of electricity.

The cost of transporting refined petroleum products by airplane and by barge to the remote villages in the North Slope area is extremely expensive. In the village of Wainwright, for example, fuel oil sells for $2.06 per gallon and gasoline is selling for $2.60 per gallon.

The North Slope Borough is currently assessing the feasibility of using local deposits of coal for space heating and for the generation of electricity in some of the villages on the North Slope. The economics of operating a small-scale, coal-fired project in a Native village will make it necessary to obtain the coal at the cost of mining and transporting the coal to the site of use.

The Department of the Interior has in the past interpreted its responsibilities to Alaska Natives living in and near the NPR-A to include granting the right to extract coal from the NPR-A in quantities sufficient for single-household use. The Department believes, however, that it does not have authority to permit an Alaska Native village to extract sufficient quantities of coal from the NPR-A to fill the heating needs of the village or fuel an electrical generation station. I am attaching to my statement a copy of a letter which sets forth the position of the Interior Department.

If the fuel needs of the Natives for heating and electric generation could be supplied by coal rather than oil, the economic burden now being borne by the Native villagers could be significantly lessened. In addition, use by the villages of coal rather than oil would be a contribution toward reduction of the country's dependence on foreign oil.

The measure I am introducing today would amend section 102 of the Naval Petroleum Reserves Production Act of 1976 to grant to the Secretary of the Interior clear authority to issue whatever permits, licenses, leases, easements, or rights-of-way are needed to permit the extraction of coal from lands within the NPR-A for local use. The authority would permit coal to be taken by the North Slope Borough, any other local governmental entity, or any Native organization within the North Slope Borough, without the payment of any royalty. The purposes for which the coal could be utilized would be limited: to provide fuel for heating or for the generation of electric power within the North Slope Borough.

The NPR-A was created in 1923 as a source of oil for the ships of the Navy in time of war. Jurisdiction over the reserve was transferred to the Department of the Interior in 1977 by the Naval Petroleum Reserves Production Act of 1976—Public Law 94-258. The known reserves of coal within the NPR-A are very significant, and the speculative reserves are estimated to equal a significant portion of the entire Earth's reserves. Identified coal reserves within NPR-A are estimated to be 44 billion tons, while total reserves are probably several times this figure.

The feasibility study prepared for the North Slope Borough estimates a requirement of approximately 3,000 tons per year for this project. At present, however, and for the immediately foreseeable future, there is not a commercial market for the coal which could be mined within the NPR-A. The primary reason for this is the lack of a transportation system which could economically move commercial quantities of coal from the North Slope to potential export markets.

The North Slope Borough had a feasibility study prepared to examine the feasibility of constructing a coal-fired generating plant for the village of Wainwright. The recommended site for coal development is only one-half mile from the village of Wainwright. The coal at this site is approximately 6 feet thick, comprised of subbituminous and lignite coal with an approximate Btu content of 12,000 Btu's per pound, a sulphur content of approximately 0.4 percent, and an ash content of between 10 to 12 percent.

As required by the Surface Mining Control and Reclamation Act of 1977, the National Academy of Sciences completed an in-depth study of surface mining conditions in Alaska in the fall of last year. This study concluded that only small-scale operations should be allowed on the North Slope until more is known about the effect of mining on the fragile Arctic environment, but recognized that mines of a limited size might not be economical. The bill I am introducing today would permit the development of small-scale mines, as recommended by the National Academy of Sciences. The development of limited-size mines would serve the dual purposes of providing the residents of the North Slope with energy from a local resource and providing a site, as recommended by the National Academy, for the testing and developing of mining and reclamation techniques which can be used on the North Slope.

The Congress, as well as the executive branch, have approved numerous actions over the last several years so that the energy resources of Alaska could more expeditiously be explored and developed in order to contribute to the energy needs of the rest of the country. However, none of those developmental activities has or will serve to assist the Native people of Alaska in reducing their dependence on expensive petroleum products. The energy resources of Alaska which are being tapped are being transported to the lower 48 States for the heating of homes and fueling of the Nation's industry. While use of those resources in the rest of the country is desirable and beneficial, it seems that it would be a small step to make available to the Alaska Natives an energy source which exists, literally, in their backyard and which is present in far greater quantities than will ever be commercially developed.

I am hopeful this bill will receive rapid consideration so that planning for the village generating stations can proceed expeditiously and the isolated citizens of the North Slope of Alaska can thus begin to recognize a measure of energy independence.●

II

97TH CONGRESS
2D SESSION

S. 2063

To amend the Naval Petroleum Reserves Production Act of 1976 to authorize the Secretary of the Interior to permit local entities to extract and use coal from lands within the national petroleum reserve in Alaska for heat and generation of electricity.

IN THE SENATE OF THE UNITED STATES

FEBRUARY 4 (legislative day, JANUARY 25), 1982

Mr. MURKOWSKI (for himself and Mr. STEVENS) introduced the following bill; which was read twice and referred to the Committee on Energy and Natural Resources

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A BILL

To amend the Naval Petroleum Reserves Production Act of 1976 to authorize the Secretary of the Interior to permit local entities to extract and use coal from lands within the national petroleum reserve in Alaska for heat and generation of electricity.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section 102 of the Naval Petroleum Reserves Production Act of 1976 (Public Law 94-258; 42 U.S.C. 6502) is amended by striking out "and (3)" and inserting in lieu thereof: "(3) grant such permits, licenses, leases, easements, and rights-of-way to the North Slope Borough, any other local governmental entity, or any native organization within the North Slope Borough, without royalty payments, as may be necessary for the extraction and use of coal as a fuel for heating and for the generation of electric power within the North Slope Borough, and (4)".

○

STATEMENT OF CURTIS V. McVEE, STATE DIRECTOR, ALASKA, BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR

Mr. McVEE. Thank you, sir. Senator, I'm pleased to appear today and provide a statement from the Department of the Interior on S. 2063.

S. 2063 would amend section 102 of the Naval Petroleum Reserve Production Act of 1976 to authorize the Secretary of the Interior to issue permits, licenses, leases, easements, and rights-of-way to the North Slope Borough for the extraction of coal. These could also be issued to other local government entities and any Native organization within the North Slop Borough. The bill provides that there would be no royalty payments, and that the coal could be used for a fuel for heating and for generation of electric power within the North Slope Borough.

We have no objection to the enactment of S. 2063, if it is amended to address our concerns.

The Mineral Leasing Act gives the Secretary the authority to issue limited licenses to individuals or associations of individuals to extract coal from the public lands. The coal may not be sold and is limited to strictly local domestic needs for fuel. No bonus, royalty, or rental payments are assessed against the holder of such a limited license. However, the Naval Petroleum Reserve Production Act of 1976 withdrew all land within the National Petroleum Reserve in Alaska from disposition under the public land laws, including the mineral leasing law. There's currently no authority for the Secretary to issue a limited license to individuals or associations of individuals to extract coal from the national petroleum reserve in Alaska. S. 2063 would give the Secretary that authority.

We do not believe that coal extracted from the public lands for which no royalties have been received should be used for profit. S. 2063 would allow the use of coal from the National Petroleum Reserve in Alaska for heating residences and village buildings, as well as for heating kilns, smelting factories, and other commercial operations for which coal can supply heat. This unrestricted concept of heating should be modified to reflect what we believe is the intent of the bill: That coal may be extracted under license to mine only for nonprofit uses. The Mineral Leasing Act allows the Secretary to issue a limited license to individuals or associations of individuals to use coal from the public lands for strictly local domestic needs. The coal may not be sold without payment of royalty. In the case of a municipal corporation, the Secretary may issue a limited license if the coal is disposed of without profit to residents of the municipality for household use. We believe S. 2063 should prevent coal from the national petroleum reserve in Alaska or the power it generates from being sold or otherwise disposed of at a profit.

S. 2063 would authorize the Secretary to issue licenses for—to local government entities and Native organizations, but not to individuals in the North Slope Borough. The Alaska National Interest Lands Conservation Act allows subsistence use of wild, renewable resources, but coal is not included among these. To assure that the current practice of allowing Natives to extract coal for household use has a sound legal basis, we recommend adding the phrase "or individual Alaska Native" after the words "any native organization."

Our report on S. 2063 would include specific recommendations to assure that the only entities affected by the bill would be Alaskan governmental or native entities. If the intent is to limit the bill's application to the extraction of coal located within the North Slope Borough, then it should be stated in the bill. And we will forward recommended language to that effect in our report.

As I stated earlier, S. 2063 would allow the Secretary to grant permits, licenses, leases, easements, and rights-of-way without royalty payments. We have been informed that the intent of this provision is to exempt the beneficiary of the licenses or permits from application fees and charges, and from rental fees and royalty payments. To insure that the bill is not interpreted to mean an exemption only from royalties on the coal, the bill should specify exactly what fees and charges are covered by the exemption. We would object to an exemption from application fees, except where the application is filed by a relief agency. We do not object to eliminating the royalty on rental and recommend that the bill be amended to explicitly limit such an exemption to royalties, rentals, and bonus payments. In similar situations under the Minerals Leasing Act, an application fee is assessed only—is assessed unless the application is filed by a relief agency. Bonus, royalty, and rental payments are not assessed. We believe that the privilege granted under S. 2063 should not exceed those granted to others under the Mineral Leasing Act.

And that concludes my statement. I'll be pleased to respond to any questions, which you may have.

Senator MURKOWSKI. Thank you very much, Curt. How quickly do you anticipate that the Secretary might grant any applications for licenses or permits, if this legislation were authorized? What kind of a timeframe do you think we might be under?

Mr. MCVEE. I would expect that, you know, we'd be looking at—oh, a 60 to 90 day timeframe. That—It would be the NPRA compliance requirement. And if that requirement—If we can accommodate that requirement through environmental analysis versus an environmental statement is required, those have been taking—because of certain publication time frames—anywhere from 12 to 18 months.

Senator MURKOWSKI. Do you have any knowledge of old coal mine activity in the area that was for local use? It's my understanding that near Wainwright there's an old mine, and they used to take coal out, and they used to bring coal clear to Barrow.

Mr. MCVEE. Yes; it's my understanding—I'm sure there's probably people here that know a lot more than I do about it—but it's my understanding that there was previous use of coal at Wainwright, and, also, I believe, at Atkasuk.

Senator MURKOWSKI. And that was curtailed when the reserve was basically put together?

Mr. MCVEE. Yes. It—there may have been other reasons, but it was hauled under—had been hauled——

Senator MURKOWSKI. There was no further authority once that legislation was authorized?

Mr. MCVEE. Right. Yes, sir.

Senator Murkowski. Under the bill, should we treat lands that are leased for local entities and their use differently than all other minerals leased under the Mineral Leasing Act specifically by not charging rentals or royalty fees? I mean, the basic concern is why, because I think this is a question that we can anticipate being asked: Why should we make this exception, if you will?

Mr. McVee. Well, I think there should be this exception in that—well, basically for the reason that there's a resource that is local, and it is available to the local people as a source of energy to compensate for the high cost you mentioned in your introductory statement of shipping in refined products, oil, and that—that the communities for—you know, it's a standard kind of municipal operation. The stores, and shops, and the homes, and the schools, and so on, should have access to that. And I think that is in keeping with some of the language within the Mineral Leasing act. I guess part of——

Senator Murkowski. Well, I think in the Mineral Leasing Act, it makes some references to the uniqueness. Could you explain for the record why this is unique?

Mr. McVee. I think it's unique in that under the Mineral Leasing Act, it allows it for heating. And we're talking about—in this circumstance—of allowing coal to be used for generation—as a basis for generation of power. I think that is the difference. And we don't see that as a precedence that would cause any problems in the Department of the Interior.

Senator Murkowski. I assume the other uniqueness is that there is no other alternative use for this at this time. It's a small amount. You have to bring in fuel by barge or fly it in.

Mr. McVee. Yes.

Senator Murkowski. Because I suspect that some of my colleagues might say, why in Alaska do we have to make an exception? And that's what I was primarily getting at, Curt.

Mr. McVee. Yes. You know, I think the extremely high cost of fuel—I don't know what's currently being paid, but a year or so ago I remember some visits to the villages on the Slope, that the price per barrel of heating fuel was $130/135 per barrel.

Senator Murkowski. Well, that's certainly unique. How could the extraction of coal under this legislation by incorporated in any department plans on mineral resources within the North Slope Borough? You know, for example, does the mineral development relate in any way to management plan for the naval petroleum Alaska developed by the Department of the Interior in your area of responsibility?

Mr. McVee. The plans that were developed as a requirement of the Naval Petroleum Production Act, section 105(c) of the act, you know, do not get into detail in terms of developmental proposals. However, the operations as I would interpret to be anticipated by this bill, I could—I would feel that they would not be—would be adverse or not in keeping with that study or with those plans. It—You know, this is very localized use. It's a small quantity of material that would be extracted and used, and I don't think it's incompatible with any of the plans that we've developed for the NPRA.

Senator Murkowski. Good. I want to thank you very much, Mr. McVee. I think your testimony has been very worthwhile in assisting in the establishment of the record. And we'll look forward to presenting you with some fast track legislation, and you can proceed, hopefully, with the licensing process.

Mr. McVee. OK. Thank you, Senator.

Senator Murkowski. Our next witness is Mr. Phil Deisher, representing the Governor of Alaska, Governor Jay Hammond. Phil needs no introduction to Fairbanks, so I won't give him one. We'll look forward to your testimony, and wish you a good morning.

STATEMENT OF PHIL DEISHER, FAIRBANKS SPECIAL ASSISTANT TO GOVERNOR JAY HAMMOND, STATE OF ALASKA; ACCOMPANIED BY GIL EAKINS AND ROY MERRITT

Mr. Deisher. Thank you, Senator, and good morning to you. Just for the record, my name is Phil Deisher, the Fairbanks Special Assistant to Governor Jay Hammond. And what follows is the administration's position on S. 2063.

The State of Alaska wholeheartedly supports S. 2063 introduced by Senator Murkowski. Although the bill deals with Federal lands, our geologists have looked at the coal potential of NPRA and have identified several high-grade large deposits of bituminous coal, as well as the potential for several smaller fields. Most of the coal reserves are concentrated in the western portion of the NPRA. Indicated and inferred reserves are in the range of 100 billion tons with several hundred billion tons of hypothetical reserves possible. Indeed, a more appropriate name for the national petroleum reserve—Alaska would be the national coal reserve. On the other hand, little detailed information about the coal resources of the area is available.

Although the coal reserves of the North Slope of Alaska are vast, they are not currently economically minable for export to the lower 48 or other Pacific rim nations. The difficulty of access, the absence of transportation facilities and the harsh environment of the North Slope will make coal mining there an expensive and challenging task. The experience gained in small scale mining for local use should provide invaluable—should prove invaluable to future efforts to develop the vast reserves of the North Slope, and will provide additional benefits to the Nation.

North Slope village residents bear some of the highest energy costs in the world, a fact in startling contrast to their proximity to some of the world's largest deposits of oil, gas, and coal. Senator Murkowski's bill would open the door to one possible solution to several of those villages' energy problems, and we therefore urge its adoption.

That basically concludes the administration's testimony, Senator, with the exception to add that Gil Eakins and Roy Merritt of the State's department of natural resources are here, and they have agreed to respond to any technical questions you might have on the NPRA coal reserves.

Senator Murkowski. Thank you, Mr. Deisher. I might ask: What, in your opinion, would the State derive from information obtained from a demonstration project in an Arctic area like Wainwright?

Mr. Deisher. What would we derive, sir?

Senator **Murkowski**. Yes. The benefits to the State in this demonstration project, assuming it went ahead.

Mr. **Deisher**. OK. Not being a geologist myself, I'd have to guess, but we have vast coal reserves, as you're well aware, all over the State, and I think mining them under such harsh conditions as these would certainly provide additional data for doing it elsewhere throughout the State. As you're aware, there are numerous coal reserves untapped in Alaska, and part of that is transportation; part of it's the climate; the geological—or just geographic sort of contours of the land. And I think that any information gained in this kind of project would be useful anywhere in the State.

Senator **Murkowski**. Do you know if the State department of natural resources has studied the feasibility of construction of similar type projects in other parts of Alaska adjacent to coal reserves?

Mr. **Deisher**. Not to my knowledge, sir. Perhaps either Gil Eakins or Roy Merritt would be better equipped to answer that. They've done some geological survey, but whether they've actually investigated the feasibility of such construction, I have no idea.

Senator **Murkowski**. I thought your remark of "recoining", if you will, the naval petroleum reserve to national coal reserve is probably quite appropriate. It seems to be a time for recoining portions of the Arctic. Yesterday in the Arctic, a research hearing that we had at the University of Alaska on the proposed legislation to establish an Arctic research policy, Max Brewer indicated that we ought to change the name of the Naval Petroleum—or, excuse me—the NARL to the National Arctic Research Lab, which I thought was an appropriate recoining. With having said very little, I want to compliment you for having said very little, I want to compliment you for having said a great deal, Phil.

Mr. **Deisher**. Thank you, sir.

Senator **Murkowski**. Thank you for your testimony. It will assist in the record, and we'll certainly thank Governor Hammond, and wish you a happy Easter.

Mr. **Deisher**. Thank you.

Senator **Murkowski**. Our next witness will be Mr. Ralph Anderson, special assistant to the mayor of the North Slope Borough, from Barrow. It's a pleasure to welcome Mr. Anderson to the hearing this morning, and welcome him as our third witness. Having had breakfast with him, I can assure you that I don't think he's hungry! The testimony, of course, that he will be giving is the tesimony of Mayor Eugene Brower, mayor of the North Slope Borough, in support of the bill S. 2063. And I welcome you to the committee this morning, and look forward to the testimony which you are going to give.

STATEMENT OF RALPH ANDERSON, SPECIAL ASSISTANT TO THE MAYOR, NORTH SLOPE BOROUGH, BARROW, ALASKA

Mr. **Anderson**. Thank you. Senator Murkowski, I'm here today to testify on a bill which will significantly improve the economic conditions of the residents of the North Slope and help us attain energy self-sufficiency. While the North Slope of Alaska is the major supplier of the Nation's domestic energy resources, it's a region where the local population's becoming increasingly energy deficient. Except for Barrow, which is supplied with natural gas, the energy needs of the other villages in the North Slope Borough are met by fuels that must be barged in or flown in at great expense. The results of this illustration—the results of this is illustrated by recent prices for fuels in Wainwright, where the costs are double those in the lower 48. This problem poses serious threat to the economy of the borough. We're prepared to handle this problem ourselves with the help of this legislation by switching from expensive oil to using coal to meet our energy needs.

The proposed bill amends the Naval Petroleum Reserves Production Act to authorize the Secretary of the Interior to permit local governments or Native organizations to mine and use coal from NPRA for heating and power generation. For some years, the Department of Interior has allowed small mining—has allowed mining small amounts of coal from NPRA for household use only. Now, the borough proposes to mine coal in the amounts needed to meet the energy needs of two small villages. The Interior Department advises us that it currently lacks the legal authority to permit these mining operations. Passage of this bill will grant the needed authority to the Department, so that coal within the NPRA can be put to good use.

Senate bill 2063 is the most straight forward, nonbureaucratic way to open these reserves to local use. The Secretary of the Interior will have the authority to develop whatever regulations are necessary both to expedite this process and to prevent any possible abuse.

NPRA is estimated to have at least 44 billion tons of coal. Perhaps up to one-third of the Earth's coal resources are there. Because of the large cost of transporting this coal to faraway markets, a commercial market has not been identified and none are anticipated to develop in the immediate future. The most significant and beneficial use for this caol is to supply power and heat to our villages. The North Slope Borough has commissioned studies to determine whether this coal can be economically and practically used to meet the energy needs of our villages.

A study done in April 1980 concluded that the average household of the North Slope Borough pays $3,388 annually for heating purposes alone. The cost for coal heating would be half that currently being paid for fuel oil. A more recent study concluded that the present system of using fuel oil is more than twice as expensive as any of the alternate coal-fired systems under consideration. That study was commissioned by the North Slope Borough in 1980 to determine the feasibility of constructing a coal-fired facility in Wainwright. This study shows that the construction and operation of such a facility is technically feasible as well as confirming its cost effectiveness.

The borough currently is considering several alternative systems identified in the study. In addition, they have identified the site near Wainwright, which would be a good location for an underground mine. Estimates of the amount of coal needed from the mine to fuel the system finally adopted range up to 10,000 tons annually. Wainwright and Atkasuk are the two most immediate places where integrated coal-fired systems may be installed. Both are within the boundaries of NPRA and near coal deposits.

There is some irony in the fact that both village corporations own surface land rights under the terms of the Alaska Native Claims Settlement Act. Where it not for the 1923 Executive order designating these lands as part of the naval petroleum reserve, the native regional corporation ASRC would now own the subsurface rights. This would have entitled them to use this coal without special legislation.

Senator Murkowski, this legislation is needed for another reason, directly related to the need to become energy self-sufficient. Economic conditions in our villages are bleak and employment opportunities are scarce, but the costs of essentials of life are much higher than in lesser remote communities. This legislation will help to stimulate our local village economies with job opportunities and low cost energy. Under the bill, the coal may be used only in the borough and only for electrical generation or heating purposes. These uses will always be clearly identified. Only those villages located in NPRA and situated near coal deposits will be able to use the coal. There are no major industries now in a position to benefit from such coal use. Further, there is substantial question whether the villages and the borough would ever permit the construction of a large scale transmission facility. Should a major industry ever develop which could benefit from this legislation, Congress could always reevaluate it, and perhaps amend it.

Senator Murkowski, I've referred before to the roles of Alaska and the North Slope and the roles that they play in supplying energy to our Nation. It's ironic that the citizens of this region are energy poor, while directly underneath their village lies the resource needed to meet their energy needs. Our residents seek energy self-sufficiency. To achieve this goal, we request permission to extract small amounts of coal from a truly vast reserve. Under these conditions, it's only fair to allow the people of the North Slope Borough to use its abundant resource to meet their needs. It would allow people to struggle against a harsh environment to proudly maintain their way of life. Passage of this bill would ease our burden and would make us, just as the rest of the Nation, beneficiaries of Alaska's great stores of energy.

I'll respond to any questions that you might have.

[The prepared statement of Mayor Brower follows:]

Testimony of Mayor Eugene Brower, Mayor, North Slope Borough in Support of S. 2063

Before
The Subcommittee on Energy and Mineral Resources of
the Committee on Energy and Natural Resources
of the United States Senate
Fairbanks, Alaska
April 8, 1982

The North Slope of Alaska is a major supplier of the nation's domestic energy resources. It is also a region where the Native population is becoming increasingly energy poor. With the exception of Barrow, which has its own unique supply of natural gas, the heating and electrical generation needs of villages in the Borough are met by refined petroleum products which must be imported--that is, barged or flown in at great expense. Direct use of the vast crude oil and natural gas reserves from nearby Prudhoe Bay is not economically possible or practical at this time. The result of this situation is illustrated by recent prices for oil products in the Village of Wainwright: $2.35 per gallon of fuel oil, and $2.80 for a gallon of gasoline--roughly twice the cost in the "Lower 48". High costs for liquid energy pose a serious threat to the life and economy of the Native people of the Borough. We are prepared to handle this problem ourselves--with the help of this legislation--by switching from expensive oil to using local coal for space heating and electrical generation.

S. 2063 would amend section 102 of the Naval Petroleum Reserves Production Act of 1976 ("NPRPA") to authorize the Secretary of the Interior to permit entities of local government or Native organizations to extract and use, without payment of royalties, coal from the National Petroleum Reserve in Alaska ("NPRA") for heating and generation of electrical power within the Borough. In an important sense this legislation would benefit not only the Native citizens, but the nation as a whole, by allowing the creation of a demonstration project--the first ever to attempt systematic extraction of even a small part of the vast coal reserves in the fragile and harsh Arctic environment of the North Slope.

The NPRA, formerly the Naval Petroleum Reserve No. 4, contains a vast amount of coal. Estimates vary, but identified reserves have been set at as much as 44 billion tons, with estimates of the entire resource in NPR-A ranging up to several times this amount. Because of excessive costs of transporting this coal to faraway markets,however, this coal has no currently identifiable commercial market or value, and none is anticipated in the immediately foreseeable future. The one available significant beneficial and direct use for the coal, therefore, is to supply power and heat to two small Native villages--one with a population of 405, the other with a population of 107.

For some years the Department of Interior has permitted, under authorities in the Mineral Lands Leasing Act of 1920 and the NPRPA, the random and sporadic extraction of very small amounts of coal from the NPR-A for household use only. Now, however, that the Borough proposes to mine coal in the amounts needed to serve the energy needs of two small villages, the Department advises us that it lacks the legal authority to permit the necessary small scale mining operations. Passage of S. 2063 will grant the needed authority to the Department so that coal within the NPR-A may be extracted and put to local use. And from the initial use by our people may develop the knowledge and technical skills necessary fully to open these reserves for the entire nation's use--either directly or by export to Pacific Rim nations.

The North Slope Borough has commissioned assessment and feasibility studies to determine whether this coal can be economically and practically used to supply fuel for heating and electrical generation to the Native villages. The conclusion is that this coal may be so used. A study done in April of 1980 concluded that the average household in the North Slope Borough requires 1,694 gallons of fuel oil on an annual basis for heating purposes. At $2.00 per gallon or $14.66 per million Btu's, this amounts to an annual cost of $3,388 per home for heating purposes alone. In contrast, it costs $736 to heat the average midwestern household with fuel oil in 1980. Estimates on the cost of mining coal from the lands within the NPR-A vary widely, from $30 to $200 per ton or $1.40-$7.40 per million Btu's. Thus, even if the high end of the cost projection is applicable, the cost for coal for heating would be half that being paid for fuel oil.

Another study, independently conducted and based on 1980 data from Fairbanks, where coal as well as oil is available on the retail market, and the only place in Alaska where a direct comparison between oil and coal is possible, concluded that coal is about 60 percent less expensive than oil, and that fuel savings for some Alaska villages could be much greater with a change from oil to coal.

A more recent study done by Arctic Slope Technical Services, Inc. ("ASTS"), for the Borough, on the feasibility of integrated units to produce both heat and power from coal, concluded that the present system of using all fuel oil is more than twice as expensive as any of the alternate coal-fired systems under consideration.

A feasibility study by ASTS noted above was commissioned by the North Slope Borough in 1980 to determine whether a coal-fired space heating and electrical generation facility might be constructed at the Village of Wainwright. This study--critical volumes of which have only just been completed--shows that the construction and operation of such a facility is technically feasible, as well as confirming its cost effectiveness. The Borough currently is studying several alternative systems identified in the study.

ASTS also notes that a site about one-half mile from Wainwright would be a good locaton for a mine, which it recommends to be underground for reasons of cost effectiveness as well as adaptability to the environment and to the structure of the coal deposit itself. Estimates of the amount of coal needed from the mine to fuel the system finally adopted vary considerably, ranging up to 10,000 tons annually, but a range of 2,000- 4,000 tons annually is a frequent assessment. One ton of coal occupies 35.18 cubic feet. Four thousand tons of coal can be mined from an area with dimensions of 20, 80, and 90 feet. Mining this amount would hardly cause a major environmental impact.

Wainwright and the Village of Atqasuk (not the subject of current assessment) are the two most likely places where an integrated coal-fired heating and electrical generation system might be installed. Both are within the boundaries of the NPR-A, and both are near known deposits of coal. There is some irony in the fact that both villages (through their respective village corporations) own the surface land rights where they are situated, under the terms of the Alaska Native Claims Settlement Act of 1971. Were it not for the Executive Order reserving these lands as part of the Naval Petroleum Reserve No. 4 in 1923, each village--under the Alaska Native Claims Settlement Act of 1971--would, like most other villages in Alaska, own through their regional corporation the subsurface rights where they are located, thus entitling them to use this coal--their coal--without the necessity of this legislation.

This legislation is needed for another reason, but one that is directly connected with the need for energy self-sufficiency among our resident population. Economic conditions in Native villages are bleak. Employment opportunities are scarce. The costs of all the essentials for life are significantly higher than in less remote communites. This legislation will help to stimulate these local economies in several ways.

The mining and generating system operations will provide employment opportunities. In small communities like Wainwright or Atqasuk the creation of a few jobs can be a great boost to the local economies. Moreover, the jobs associated with mining and other operations will tend to be skilled in nature--thus, further boosting and sustaining the work skills of the local work force, who will be heavily utilized in these installations.

Moreover, as already noted, these coal-fired facilities will lower the cost of energy by as much as one half. This development will, of course, aid the local economy. The fact that no royalty will be charged for the coal, however, is critical in realizing the benefits of these cost savings. Capital investment and other start-up costs for these projects will be great. As a demonstration project, it will of course be pioneering in an area where these expenses are particularly subject to uncertainties. The requirement of paying a royalty would add unnecessarily to these expenses, and when added to other operating and mining costs, might make these planned projects uneconomical and infeasible. Furthermore, since the coal has no commercial value due to the lack of economical transportaton to significant markets, there should be no objection to a disposition of it without payment of royalty--since this disposition involves the only way in which use of the coal can economically benefit any group in the foreseeable future.

Development of the coal in this manner may, as I have already suggested, prove to be the precursor of further development and utilization of these resources. As required by the Surface Mining Control and Reclamation Act of 1977, the National Academy of Sciences has completed a study of surface mining conditions in Alaska. This study concluded that only small scale operations should be allowed on the North Slope until more is known about the effect of such mining on the fragile Arctic environment, but recognized that mines of a limited size might not be economical to operate.

S. 2063 would provide a means to experiment, on a scale suggested by the National Academy of Sciences, with mining techniques in the Arctic. This is a project that other organizations or corporations might be unwilling to undertake because of its potentially uneconomical nature. The Borough could then be furthering the interests of the whole nation, as well as of its own residents, by the development of a national resource. The potential economic benefits to the nation as a whole must, therefore, be assessed as part of the benefits--perhaps the greatest benefit--to be derived from allowing this coal demonstration project to go forward.

One of the studies that we have commissioned already indicates that the environmental effects of these contemplated operations will be well within permissible levels. Unless the population of the Borough increases drastically by the year 2000, thereby increasing the need for coal use, the effect on the environment will be minimal because local coals have low ash and sulfur content. There is, furthermore, no problem anticipated with rehabilitation of the land, especially if underground mines are used.

S. 2063--an amendment to section 102 of the NPRPA--is the most straightforward, non-bureaucratic way to open these reserves to Native use. The Secretary of the Interior will have the authority to develop whatever regulations are necessary both to expedite this process and to prevent any possible abuse. Amanding other laws, such as the Mineral Lands Leasing Act of 1920, seems to us to present unnecessary problems and possible bureaucratic entanglement which we could avoid simply by amending the NPRPA.

Under the amendment the coal may be used only in the Borough and only for electrical generation or heating purposes. These uses will, of course, always be clearly identified. Only those villages located in the NPR-A and situated near deposits of coal will be in a position to use it. There are no major industries now in a position to benefit in any way from such coal use. The oil-production facilities at Prudhoe Bay are too far away from coal deposits and villages to benefit. Further, there is a substantial question whether the Villages in the Borough would ever permit the construction of large scale transmission facilities. Should a major industry ever develop which could benefit from this royalty-free coal by purchasing power or heat from a village operation, the Congress could always at that time reevaluate this legislation and perhaps amend it.

If any of the circumstances underlying this legislation should substantially change--in particular, should this coal ever become commercially exploitable--we recognize that the Congress may want to reconsider the no-royalty provision. But in view of the enormous and otherwise unusable reserves available, there seems every reason to permit the only direct beneficial use which can be made of them at this time.

I have referred before to the great role which Alaska and its North Slope have played in supplying energy to the nation. It is, therefore, a paradox that the citizens of this great region are energy poor while directly underneath their villages lies the resource--coal--needed to meet their energy needs. Our native residents seek only the goal of the rest of the nation--energy-self-sufficiency and decreased dependence on overseas supplies of energy. To achieve this goal of energy self-sufficiency, they seek permission to extract small amounts of coal under their villages from a truly vast reserve.

Under these circumstances, it is only fair to allow the Native people of the North Slope Borough to use this abundant natural resource for their essential needs. Their initiative and ingenuity in promoting this coal demonstration project, moreover, may lead to opening up these Arctic coal resources to the effective use of the entire nation. These are people who struggle against a harsh environment in a largely subsistence economy to maintain proudly their way of life. Passage of S. 2063 would ease their burden and make them, just as the rest of the nation, beneficiaries of Alaska's great stores of energy.

Senator **Murkowski**. Thank you very much, Mr. Anderson. I would like to advise for the record that the entire testimony, which is before the chair, will be submitted in the record, which I assume is your intent, because in following your testimony, I noticed in the interest of brevity that you did make certain summaries for which we're very appreciative. So, the record will so note.

I might ask a couple of brief questions. With regard to the intention to finance construction eventually of the pilot project, is this anticipated to come from a special tax assessment on residents, or how does—how do you get the money to build it?

Mr. **Anderson**. Like any other capital improvements project that we have, you know, the borough sells bonds based on our—the assessed value of the borough. You know, unfortunately back in 1973, the State legislature put a ceiling on our millage rate, which will have some effect on, you know, the amount of revenue that we're able to generate for this project.

Senator **Murkowski**. I see. But you do not intend to have any difficulty financing it, basically?

Mr. **Anderson**. No.

Senator **Murkowski**. Do you have any plans or might we see a further development if it proves successful in other areas more distant from Wainwright?

Mr. **Anderson**. Yes; we're currently planning a—well, we're looking at the feasibility of developing a similar system at the village of Atkasuk. We're also currently building a new school in the village of Point Lay, and it's being designed in such a manner that it may some day be converted to coal—coal heating.

Senator **Murkowski**. How far is the village of Atkasuk from Wainwright?

Mr. **Anderson**. Well, the village of Atkasuk is somewhere in the neighborhood of 60 miles from Barrow. I'm not sure.

Senator **Murkowski**. OK. I assume that you would anticipate utilizing residents of the borough to excavate or whatever process is going to be used in mining and also for the operation of the plant itself?

Mr. **Anderson**. Yes. Like I, you know, stated in the testimony this morning, our economy and job opportunities aren't the greatest, because, see, the borough is—you know, currently provides most of the employment opportunities on the North Slope, and we have a very strong local hire policy and local employment policy.

Senator **Murkowski**. As you are aware from the earlier testimony, the Department of Interior has recommended that this bill be amended to insure that coal only be used by nonprofit entities or individual Alaska Natives within the North Slope Borough for nonprofit purposes. Could you comment for the record on that? Do you see any difficulty with it staying in the nonprofit area?

Mr. **Anderson**. No. Because the—you know, the transportation system for this coal would—you know, first of all, is nonexistent; and, second, it would be very expensive, you know, to put into operation. You know, it doesn't look very likely that one will develop.

Senator **Murkowski**. With the operation of the powerplant, once it's assumed to go in, you would operate it at a cost basis, because the profit situation here is one that is rather of a concern. It would cover, I assume, your costs, but it wouldn't necessarily involve a profit, or would it?

Mr. **Anderson**. We're not anticipating to make any profit out of—you know—the system that we finally develop at Wainwright.

Senator **Murkowski**. We very much appreciate your testimony, Mr. Anderson. And please give our regards to Mayor Brower. And, again, to the mayor and the members of the borough, please convey our thanks to them for allowing you to come down and make this testimony on behalf of the borough.

Mr. **Anderson**. Thank you, Senator.

Senator **Murkowski**. We wish you a good day! Our next witness will be the Honorable Jacob Kagak, the mayor of Wainwright, Alaska. And, Mayor, we welcome you to the witness table, and look forward to presentation of your testimony, and we wish you a good morning. Please sit down and proceed.

STATEMENT OF HON. JACOB KAGAK, WAINWRIGHT, ALASKA

Mayor **Kagak**. Good morning, Honorable Senator, and thank you for allowing me to be here. And my special thanks to Mayor Brower of North Slope Borough for allowing us and my fellow residents over there, Mr. David Bodfish and Mr. Tom Ahvakana they're with me. I am grateful for—to be able to say a few words before you.

As most of you know, my name is Jacob Kagak. and I'm the mayor of the small village of Wainwright. I consider it an honor and privilege to be able to appear before you today in order to voice my opinions and concerns regarding the extremely important issue: That is, the proposed coal conversion project in Wainwright.

After a great deal of discussion with my associates, several engineers, and various other persons involved, and after examining the extended feasibility study and other facts at my disposal, I am not convinced that the coal conversion project is the proper course of action for my village.

On the contrary, I believe that the study has raised more questions and posed more problems than we had anticipated or were prepared for.

Some of the questions that come to mind are these: How large an area will be affected by the digging of the mine and the construction of the heating plant? What are the "liquid mine wastes," and how will they be disposed of? What is "excess spoil," and how will it be disposed of? Will there be air pollution problems created by coal smoke? Our prevailing wind is to the northwest. However, when we have a south wind or no wind at all, would we have a dense, black smoke hanging over our village?

Will Wainwright eventually be covered by smog like a big industrial city?

The study indicates that there will be no filter on the smokestack. Will the sky be darkened by smoke and haze?

What will be the effects on the ecology: Our whales, and fish, and birds, and the other animals?

They say the mine will be about 120 feet deep. Who will work down in the mine? How many of us here today will be willing to work 120 feet underground for 8 hours a day?

What other problems would arise that we do not yet anticipate? Environment problems, ecological problems, health problems?

It appears to me that the benefits that we could expect from a coal mine and a district heating plant do not outweigh the disadvantages and ill-effects, possibly long-term ill-effects, that we could expect from such a project.

I am convinced that it would create more problems than it would solve.

We are all aware of the high cost of heating our homes, and we are all seeking a better way. What are the alternatives, and what is the best way? There are a few alternatives due to our location and climatic conditions. The one that seems to be the most logical involves recently a gasfield that was—that will be operational in the near future that recently—a gasfield that was discovered approximately 70 miles north of Wainwright and what is called Walakpa Field.

We all know that the natural gas burns clean, is economical, and in our case, convenient. A natural gasline strectching 70 miles across the tundra would have a minimum impact on our landscape. It would take a short—a relatively short period of time to obtain permits and hook up, and the potential for permanent damage to our environment, our ecology, and the air that we breathe would be minimized.

On behalf of the Wainwright City Council, I would urge that this course of action be taken.

In conclusion, I would like to say that we are aware, as the initial studies indicated, that there is an abundance of valuable, easily accessible coal in the village of Wainwright, and we do consider that coal to be a priceless asset to our village. However, the majority of my fellow residents and I are convinced that it should remain undisturbed at this time, and the decision to utilize this precious resource would be left to our children and our grandchildren.

And thank you for allowing me to express our opinions, concerns, and desires.

Senator **Murkowski**. Thank you very much for that very informative testimony. And I think it certainly reflects on some of the concerns that we anticipated would be addressed by some of the following witnesses, I believe Mr. Johnson, specifically. But the statement representing the position officially of the city of Wainwright as being, I think, generally opposed to the proposal is most significant. I guess my question would be: Is your opposition based primarily because of your concern for the questions that you have, and if those questions are answered satisfactorily, is it a position that you would reconsider, or, for all practical purposes, has your decision been made?

Mr. **Kagak**. This is not a final decision. I would reconsider in the future if there is more study to it, and that—here and there a few studies, and then that——

Senator **Murkowski**. Well, I assure you that it is not the intent of this hearing to develop legislation that is contrary to the wishes of the people affected. And you have expressed very eloquently your concerns, and I think it's an obligation of the borough, who is proposing and supporting this legislation, as we have heard, and their individual representatives to respond to your concerns. And I personally will look forward to their testimony with that regard. And I would like to advise you that the record will remain open for 2 weeks, and if you wish to submit any additional material relative to the questions that you have raised, or any other material, we would be most receptive to receiving that, because I assure you, Mayor, that your testimony is very paramount in the eventual action of any proposed legislation. And it would be my general conclusion that without the support of the people of your village of Wainwright, this legislation probably would not go much further.

Mayor KAGAK. Thank you.

Senator MURKOWSKI. Let me see if I have any specific questions. How many people live in your village, Mayor?

Mayor KAGAK. Approximately 450. And that's including all the teachers and the transients.

Senator MURKOWSKI. That's a fairly average year round figure.

Mayor KAGAK. The average would be about 430 year round.

Senator MURKOWSKI. And the other village of Atka—what is it? Ankatuk? You're going to have to teach me Eskimo a little better.

Mayor KAGAK. The village of Atkasuk?

Senator MURKOWSKI. Yes; the other one that would be tied into your—this proposed plant. How far away is that?

Mayor KAGAK. Approximately 55 to 60 miles.

Senator MURKOWSKI. I see. And how many people live in that village?

Mayor KAGAK. I wouldn't know. I would have to guess. About 150; maybe even a little over 200.

Senator MURKOWSKI. Do you have some idea of what people pay to heat their homes in your village?

Mayor KAGAK. I'm glad you brought that up. From experience, last year I paid over $8,000 just on heat and fuel alone.

Senator MURKOWSKI. Just on fuel oil?

Mayor KAGAK. Right.

Senator MURKOWSKI. $8,000. How big a home do you have?

Mayor KAGAK. Sixty by forty, and there was only two of us living. That's before we got our——

Senator MURKOWSKI. 2,400 square feet, and it cost you $8,000?

Mayor KAGAK. Right.

Senator MURKOWSKI. And how many months do you heat it?

Mayor KAGAK. Approximately 6 months.

Senator MURKOWSKI. Six months.

Mayor KAGAK. The average today on heating fuel is about $500—$406 to $500 a month; $600 on these new prefabricated houses that the North Slope Borough is building.

Senator MURKOWSKI. Maybe they ought to build tighter houses?

Mayor KAGAK. They should.

Senator MURKOWSKI. I said that; you didn't, huh? What other buildings—I haven't been in Wainwright in several years. What other buildings, other than homes, are located—you've got the school——

Mayor KAGAK. We've got the high school, and we've got the community center. We've got a clinic, a couple of churches, and post office, and there's about three or four local stores.

Senator MURKOWSKI. Is there any interest in local employment in the development of this mine for coal?

Mayor KAGAK. At the last meeting with the people that were doing the feasibility study on this coal mine, that was one question to the villagers, and nobody seems to be interested, because I guess they didn't understand, or maybe they understood how it is to work 120 feet underground in the coal——

Senator MURKOWSKI. Did any of the elders remember the old mine there?

Mayor KAGAK. I do remember, too, because I did extract coal for heating fuel when I was about—early teenage years.

Senator MURKOWSKI. How far down does that tunnel go?

Mayor KAGAK. Well, I would say about 10–15 feet.

Senator MURKOWSKI. So, in those days, you could just go in and—what?—take a pick and pick the coal off the wall?

Mayor KAGAK. In sacks, and then about 7 miles out of town, too.

Senator MURKOWSKI. Nobody does that anymore?

Mayor KAGAK. I might be wrong, but I think there's a few families that still do it. Maybe——

Senator MURKOWSKI. What is the rate of unemployment in your village? Do you know offhand?

Mayor KAGAK. Offhand, when the construction season is nil, I would say about 15 to 16 percent, but construction is going full right now. There's hardly any unemployment right now.

Senator MURKOWSKI. Did this matter come up before your council?

Mayor KAGAK. The feasibility study on the coal project?

Senator MURKOWSKI. The position that you have taken in your testimony——

Mayor KAGAK. Yes.

Senator MURKOWSKI [continuing]. That you're very concerned about it, and for the time being opposed to it, unless—and I don't want to put words in your mouth, but that's the way I kind of read your statement, that——

Mayor KAGAK. Right. Six out of seven councils read it Tuesday night.

Senator MURKOWSKI. So the vote was seven to six?

Mayor KAGAK. An absence of one, I think the full quorum——

Senator MURKOWSKI. Oh, OK. It was a vote of six out of seven?

Mayor KAGAK. Right.

Senator MURKOWSKI. OK. And six were opposed and one was in favor?

Mayor KAGAK. Right.

Senator MURKOWSKI. Well, I think you're——

Mayor KAGAK. No, no. I'm sorry. I didn't quite understand.

Senator MURKOWSKI. I asked if there was a vote taken on this issue before your council as to the stand that you've taken and what the vote count was.

Mayor KAGAK. We didn't vote on it. I just presented it the way it is, and then we had comments, and then I asked for any deletions or objections, and they all went along with this.

Senator MURKOWSKI. OK. So, it was accepted, then——

Mayor KAGAK. Right.

Senator MURKOWSKI [continuing]. Unanimously, in effect? Mayor, I thank you for your testimony, and we look forward to proceeding with the next witnesses as they direct their attention, I would suggest, to your concerns.

Mayor KAGAK. Thank you very much, sir.

Senator MURKOWSKI. Thank you, Mayor. Have a nice day and a happy Easter.

We are going to move around the agenda to accommodate Don Triplehorn, who will be with us shortly, and ask Mr. Leonard—Leland—excuse me—Leland Johnson, president, Arctic Slope Technical Services, to approach the witness stand with some trepidation.

Seriously, we welcome you, Mr. Johnson, and look forward to your testimony, and particularly to the concerns expressed by Mayor Kagak. If you are so inclined, please proceed.

STATEMENT OF LELAND A. JOHNSON, P.E., PRESIDENT, ARCTIC SLOPE TECHNICAL SERVICES, INC., ANCHORAGE, ALASKA

Mr. JOHNSON. Thank you. I do have prepared testimony, which because it has been prepared and offered in written text, perhaps I would be best advised to go ahead and present this testimony, and then, second, I can follow that with something that is more specifically oriented to Mr. Kagak's concern.

Mr. Chairman, and members of the subcommittee, my name is Leland A. Johnson, and I'm appearing as a representative of Arctic Slope Technical Services, Inc. We appreciate this opportunity to——

Senator MURKOWSKI. Would you—I'm going to interrupt you a little bit for the record. Would you tell us, for the record, who Arctic Slope Technical Services is? And who owns them, and what they do, and where their headquartered?

Mr. JOHNSON. I certainly will. In fact, that is a——

Senator MURKOWSKI. Is that a part of your testimony?

Mr. JOHNSON. It is a part of the presentation.

Senator MURKOWSKI. OK. Then, go ahead, please. I apologize.

Mr. JOHNSON. We appreciate this opportunity to offer testimony pertinent to S. 2063, which would amend the Naval Petroleum Reserve's Production Act of 1976, to authorize the Secretary of the Interior to permit local entities to contract and use coal from lands within the national petroleum reserves in Alaska for heat and generation of electricity.

Arctic Slope Technical Services is a multidisciplined consulting organization owned by the Arctic Slope Regional Corp., Polar Consult, Ertec, and Daniel, Mann, Johnson & Mendenhall, a combination of four firms owning the company.

The firm has extensive capability in the alternative energy fields. Of particular pertinence to this topic is our Scandanavian expertise gained with coal- and oil-fired districtwide heating schemes, which have been used extensively in Denmark and Greenland. We have coal mining expertise as well through our mining consulting office in Denver, Colo. Since early 1980, ASTS has been examining the technical and economic feasibility of coal utilization and associated central district heating schemes for two Alaskan communities. Specifically, these studies have focused on the village of Wainwright under contract to the North Slope Borough and on the city of Kotzebue under contract to the Alaska Power Authority. Since Wainwright would, in fact, be utilizing NPRA coal, I will brief you on our findings in that study effort.

Our feasibility assessment for the village of Wainwright was conducted in two separate studies. In the first study, we identified the various alternatives by which coal could be utilized as a substitute to fuel oil for heating and electrical power. Various systems utilizing coal were investigated and ranged from low temperature and low pressure liquid medium heating to coal-fired steam heat and power to gasification of coal for thermal power and heat generation. These were considered in combination with conventional oil-fired systems, windpower systems, and state-of-the-art organic rankine cycle power generating systems, and were reviewed considering the analyzed energy demands of Wainwright.

The second phase of our study concentrated on the most promising alternatives identified in our initial work, but in conjunction with a subsurface drilling program which further located, quantified, and assessed the quality of the area's coals.

The recommendations which resulted are briefly summarized as follows:

Mine location recommended is about one-half mile northeast of Wainwright's outskirts. It's considered to be the most suitable mine location based on our findings.

The mining method is recommended to be an underground operation. It would be excavating a 6-foot coal seam at about 120 feet below the surface. The method used would be "dintheader" exavator and shuttle trucks, which are mining devices which can operate in a low profile coal seam, such as this. Mining will take place in short periods, which will be scheduled to avoid the summer period and all important hunting and fishing seasons.

The testimony, incidentally, has two page 2's. I apologize for that, but——

The central—another aspect of our findings refers to central district heating. During the course of our work under the subject study, we concluded that the long-term development should be based on coal-fired low-pressure heaters providing central district heating. The existing diesel generating plant would continue to produce electricity. It was recommended that a three-phase implementation plan be followed.

Phase I would involve the development of preferred mine site, storage facilities, and a means of transportation to enable mining to take place under a limited permit. That's to say 20 tons per annum per household for individual home heating and capable of being expanded into phase II. I understand that at this limit there would be no requirement to have a legislative change. Installation of coal burning stoves or furnaces for interim use and later used as backup in individual homes, if village people show sufficient interest in such an interim usage. Implementation of retrofit energy conservation methods—measures.

Phase II would involve central district heating based on coal-fired low-pressure heaters. Phase II could be subphased to coincide with requirements of the North Slope Borough as regards funding and new housing developments.

Phase III, introduction of organic rankine cycle generation to supplant diesel generation as and when warranted by prevailing condition—conditions and needs also by emerging experience with commercially available ORC plant.

It is noted that the Alaska Power Authority is proposing to fund a pilot ORC generation plant in a northwest Alaskan village based on the firing of a solid fuel. Consideration should be given to seeking to have this pilot operation sited in Wainwright.

In both phases of our studies, we have compared the alternative approaches through cost comparison in an effort to isolate the most economic approach. There are other important considerations, however, which must be fully considered in such an investigation. Power and heating systems utilizing coal represents different, and in some instances, more complex technologies than are used with oil-fired systems. Safety becomes a special consideration should high-pressure steam be utilized in the production of electricity and heat, and depends heavily on specialized operating personnel.

In our feasibility assessments, we have placed a high priority on the level of technology associated with each system type, keeping in mind that Wainwright is a small population base from which to draw qualified operating personnel. Mining methods are also assessed considering levels of technology, which could locally be accomodated. The special nature of mining and permafrost is important, and it must be considered in concert with the economic aspects. Environmental concerns are, of course, automatically raised when coal use is contemplated. It was recognized that the proximity of a power- or heat-producing plant to the village is important, as is the importance of clean air and water are maintained and the land surface disruption is minimized. In our opinion, these requirements can be met.

For local, small-scale use the proximity of the resource relative to the villages is of utmost importance, because the cost is very sensitive to the quantity of coal mined and the distances encountered in the overland transfer of coal or electrical power or heated media.

In the case of Wainwright, the closest and probably only economically usable coal is on NPRA lands, the subsurface estate of which is owned by the Federal Government and is subject to BLM management. The BLM, of course, does not presently have the authority to issue coal leases within the NPRA.

In summary, I would state that based on our studies to date, it is improbable that coal would be a viable energy alternative for Wainwright, unless the local subsurface coals were made available to the village.

I wish to thank you for this opportunity to testify, and would welcome any questions you may care to ask.

[The prepared statement of Mr. Johnson follows:]

STATEMENT
OF
LELAND A. JOHNSON, PRESIDENT
OF
ARCTIC SLOPE TECHNICAL SERVICES INC.
ON
S.2063 - AMENDMENT TO THE NAVAL
PETROLEUM RESERVES PRODUCTION ACT OF 1976
BEFORE
THE SUBCOMMITTEE ON ENERGY AND RESOURCES OF THE COMMITTEE ON
ENERGY AND NATURAL RESOURCES OF THE UNITED STATES SENATE

FAIRBANKS, ALASKA
APRIL 8, 1982

MR. CHAIRMAN, AND MEMBERS OF THE SUBCOMMITTEE, MY NAME IS LELAND A. JOHNSON AND I AM APPEARING AS A REPRESENATIVE OF ARCTIC SLOPE TECHNICAL SERVICES, INC. WE APPRECIATE THIS OPPORTUNITY TO OFFER TESTIMONY PERTINENT TO S.2063, WHICH WOULD AMEND THE NAVAL PETROLEUM RESERVES PRODUCTION ACT OF 1976 TO AUTHORIZE THE SECRETARY OF THE INTERIOR TO PERMIT LOCAL ENTITIES TO CONTRACT AND USE COAL FROM LANDS WITHIN THE NATIONAL PETROLEUM RESERVES IN ALASKA FOR HEAT AND GENERATION OF ELECTRICITY. ARCTIC SLOPE TECHNICAL SERVICES IS A MULTI-DISCIPLINED CONSULTING ORGANIZATION OWNED BY THE ARCTIC SLOPE REGIONAL CORPORATION, POLARCONSULT, ERTEC AND DANIEL, MANN, JOHNSON, AND MENDENHALL. THE FIRM HAS EXTENSIVE CAPABILITY IN THE ALTERNATIVE ENERGY FIELDS. OF PARTICULAR PERTINENCE TO THIS TOPIC IS OUR SCANDINAVIAN EXPERTISE GAINED WITH COAL AND OIL FIRED DISTRICT WIDE HEATING SCHEMES WHICH HAVE BEEN USED EXTENSIVELY IN DENMARK AND GREENLAND. WE HAVE COAL MINING EXPERTISE AS WELL THROUGH OUR MINING CONSULTING OFFICE IN DENVER, COLORADO. SINCE EARLY 1980 ASTS HAS BEEN EXAMINING THE TECHNICAL AND ECONOMIC FEASIBILITY OF COAL UTILIZATION AND ASSOCIATED CENTRAL DISTRICT HEATING SCHEMES FOR TWO ALASLAN COMMUNITIES. SPECIFICALLY, THESE STUDIES HAVE

FOCUSED ON THE VILLAGE OF WAINWRIGHT UNDER CONTRACT TO THE NORTH SLOPE BOROUGH AND ON THE CITY OF KOTZEBUE UNDER CONTRACT TO THE ALASKA POWER AUTHORITY. SINCE WAINWRIGHT WOULD IN FACT BE UTILIZING NPR-A COAL, I WILL BRIEF YOU ON OUR FINDINGS IN THAT STUDY EFFORT. OUR FEASIBILITY ASSESSMENT FOR THE VILLAGE OF WAINWRIGHT WAS CONDUCTED IN TWO SEPARATE STUDIES. IN THE FIRST STUDY WE IDENTIFIED THE VARIOUS ALTERNATIVES BY WHICH COAL COULD BE UTILIZED AS A SUBSTITUTE TO FUEL OIL FOR HEATING AND ELECTRICAL POWER. VARIOUS SYSTEMS UTILIZING COAL WERE INVESTIGATED AND RANGED FROM LOW TEMPERATURE (AND LOW PRESSURE) LIQUID MEDIMUM HEATING, TO COAL FIRED STEAM HEAT AND POWER, TO GASSIFICATION OF COAL FOR THERMAL POWER AND HEAT GENERATION. THESE WERE CONSIDERED IN COMBINATION WITH CONVENTIONAL OIL FIRED SYSTEMS, WIND POWER SYSTEMS AND STATE OF THE ART ORGANIC RANKINE CYCLE POWER GENERATING SYSTEMS AND WERE REVIEWED CONSIDERING THE ANALYZED ENERGY DEMANDS OF WAINWRIGHT.

THE SECOND PHASE OF OUR STUDY CONCENTRATED ON THE MOST PROMISING ALTERNATIVES IDENTIFIED IN OUR INITAL WORK, BUT IN CONJUNTION WITH A SUBSURFACE DRILLING PROGRAM WHICH FURTHER LOCATED, QUANITIFIED AND ASSESSED THE QUALITY OF THE AREA COALS.

THE RECOMMENDATIONS WHICH RESULTED ARE BRIEFLY SUMMARIZED AS FOLLOWS:

MINE LOCATION: A LOCATION ABOUT 1/2 MILES NORTHEAST OF WAINWRIGHT'S OUTSKIRTS, WAS RECOMMEND AS THE MOST SUITABLE MINE LOCATION.

MINING METHOD: IT WAS RECOMMENDED THAT A 6 FT. COAL SEAM ABOUT 120 FT. UNDER THE SURFACE BE MINED UNDERGROUND USING "DINTHEADER" EXCAVATOR AND SHUTTLETRUCKS. MINING WILL TAKE PLACE IN SHORT PERIODS, WHICH WILL BE SCHEDULED TO AVOID THE SUMMER PERIOD AND ALL IMPORTANT HUNTING AND FISHING SEASONS.

FOCUSED ON THE VILLAGE OF WAINWRIGHT UNDER CONTRACT TO THE NORTH SLOPE BOROUGH AND ON THE CITY OF KOTZEBUE UNDER CONTRACT TO THE ALASKA POWER AUTHORITY. SINCE WAINWRIGHT WOULD IN FACT BE UTILIZING NPR-A COAL, I WILL BRIEF YOU ON OUR FINDINGS IN THAT STUDY EFFORT. OUR FEASIBILITY ASSESSMENT FOR THE VILLAGE OF WAINWRIGHT WAS CONDUCTED IN TWO SEPARATE STUDIES. IN THE FIRST STUDY WE IDENTIFIED THE VARIOUS ALTERNATIVES BY WHICH COAL COULD BE UTILIZED AS A SUBSTITUTE TO FUEL OIL FOR HEATING AND ELECTRICAL POWER. VARIOUS SYSTEMS UTILIZING COAL WERE INVESTIGATED AND RANGED FROM LOW TEMPERATURE (AND LOW PRESSURE) LIQUID MEDIMUM HEATING, TO COAL FIRED STEAM AND HEAT POWER, TO GASSIFICATION OF COAL FOR THERMAL POWER AND HEAT GENERATION. THESE WERE CONSIDERED IN COMBINATION WITH CONVENTIONAL OIL FIRED SYSTEMS, WIND POWER SYSTEMS AND STATE OF THE ART ORGANIC RANKINE CYCLE POWER GENERATING SYSTEMS AND WERE REVIEWED CONSIDERING THE ANALYZED ENERGY DEMANDS OF WAINWRIGHT.

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CENTRAL DISTRICT HEATING

DURING THE COURSE OF OUR WORK UNDER THE SUBJECT STUDY WE CONCLUDED THAT THE LONG TERM DEVELOPMENT SHOULD BE BASED ON COAL-FIRED LOW PRESSURE HEATERS PROVIDING CENTRAL DISTRICT HEATING, THE EXISTING DIESEL GENERATING PLANT PRODUCING ELECTRICITY. IT WAS RECOMMENDED THAT IMPLEMENTATION SHOULD BE PHASED AS FOLLOWS:

PHASE I:

- DEVELOPMENT OF PREFERRED MINE SITE, STORAGE FACILITIES AND MEANS OF TRANSPORTATION TO ENABLE MINING TO TAKE PLACE UNDER LIMITED PERMIT (20 TONS PER ANNUM PER HOUSEHOLD) FOR INDIVIDUAL HOME HEATING AND CAPABLE OF BEING EXPANDED INTO PHASE 2.

- INSTALLATION OF COAL-BURNING STOVES OR FURNACES FOR INTERIM USE AND LATER BACK-UP IN INDIVIDUAL HOMES, IF VILLAGE PEOPLE SHOW SUFFICIENT INTEREST IN SUCH INTERIM USAGE.

- IMPLEMENTATION OF RETROFIT ENERGY CONSERVATION MEASURES.

PHASE 2:

- CENTRAL DISTRICT HEATING BASED ON COAL-FIRED LOW PRESSURE HEATERS.

- PHASE 2 COULD BE SUBPHASED TO COINCIDE WITH REQUIREMENTS OF THE NSB AS REGARDS FUNDING AND NEW HOUSING DEVELOPMENTS.

PHASE 3:

- INTRODUCTION OF ORC-GENERATION TO SUPPLANT DIESEL-GENERATION, AS AND WHEN WARRANTED BY PREVAILING CONDITIONS AND NEEDS ALSO BY EMERGING EXPERIENCE WITH COMMERCIALY AVAILABLE ORC-PLANT.

- IT IS NOTED THAT THE ALASKA POWER AUTHORITY ARE PROPOSING TO FUND A PILOT ORC-GENERATION PLANT IN A NORTHWEST ALASKAN VILLAGE BASED ON THE FIRING OF A SOLID FUEL. CONSIDERATION SHOULD BE GIVEN TO SEEKING TO HAVE THIS PILOT OPERATION SITED IN WAINWRIGHT.

IN BOTH PHASES OF STUDY WE HAVE COMPARED THE ALTERNATIVE APPROACHES THROUGH COST COMPARISONS IN EFFORT TO ISOLATE THE MOST ECONOMIC APPORACH. THERE ARE OTHER IMPORTANT CONSIDERATIONS HOWEVER WHICH MUST BE FULLY CONSIDERED IN SUCH AN INVESTIGATION. POWER AND HEATING SYSTEMS UTILIZING COAL REPRESENT DIFFERENT AND, IN SOME INSTANCES, MORE COMPLEX TECHNOLOGIES THAN ARE USED WITH OIL FIRED SYSTEMS. SAFETY BECOMES A SPECIAL CONSIDERATION SHOULD HIGH PRESSURE STEAM BE UTILIZED IN THE PRODUCTION OF ELECTRICITY AND HEAT AND DEPENDS HEAVILY ON SPECIALIZED OPERATING PERSONNEL. IN OUR FEASIBILITY ASSESSEMENTS WE HAVE PLACED A HIGH PRIORITY ON THE LEVEL OF TECHNOLOGY ASSOCIATED WITH EACH SYSTEM TYPE KEEPING IN MIND THAT WAINWRIGHT HAS A SMALL POPULATION BASE FROM WHICH TO DRAW QUALIFIED OPERATING PERSONNEL. MINING METHODS WERE ALSO ASSESSED CONSIDERING LEVELS OF TECHNOLOGY WHICH COULD LOCALLY BE ACCOMMODATED. THE SPECIAL NATURE OF MINING IN PERMAFROST IS IMPORTANT AND MUST BE CONSIDERED IN CONCERT WITH THE ECONOMIC ASPECTS. ENVIRONMENTAL CONCERNS ARE OF COURSE AUTOMATICALLY RAISED WHEN COAL USE IS CONTEMPLATED. IT WAS RECOGNIZED THAT THE PROXIMITY OF A POWER OR HEAT PRODUCING PLANT TO THE VILLAGE IS IMPORTANT AS IS THE IMPORTANCE THAT CLEAN AIR AND WATER ARE MAINTAINED AND THAT LAND SURFACE DISRUPTION IS MINIMIZED. IN OUR OPINION THESE REQUIREMENTS CAN BE MET.

FOR LOCAL, SMALL SCALE USE THE PROXIMITY OF THE RESOURCE RELATIVE TO THE VILLAGES IS OF UTMOST IMPORTANCE BECAUSE THE COST IS VERY SENSITIVE TO THE QUANTITY OF COAL MINED AND THE DISTANCES ENCOUNTERED IN THE OVERLAND TRANSFER OF COAL OR ELECTRICAL POWER OR HEATED MEDIA.

IN THE CASE OF WAINWRIGHT THE CLOSEST AND PROBABLY ONLY ECONOMICALLY USABLE COAL IS ON NPR-A LANDS, THE SUBSURFACE ESTATE OF WHICH IS OWNED BY THE FEDERAL GOVERNMENT AND IS SUBJECT TO BLM MANAGEMENT. THE BLM OF COURSE DOES NOT PRESENTLY HAVE THE AUTHORITY TO ISSUE COAL LEASES WITHIN THE NPR-A.

IN SUMMARY I WOULD STATE THAT BASED ON OUR STUDIES TO DATE IT IS IMPROBABLE THAT COAL WOULD BE A VIABLE ENERGY ALTERNATIVE FOR WAINWRIGHT UNLESS THE LOCAL SUBSURFACE COALS WERE MADE AVAILABLE TO THE VILLAGE. I WISH TO THANK YOU FOR THIS OPPORTUNITY TO TESTIFY AND WOULD WELCOME ANY QUESTIONS YOU MAY CARE TO ASK.

Senator MURKOWSKI. Thank you very much, Mr. Johnson. Tell us, what type of coal is this? Is it high sulfur, low sulfur, high ash, high moisture, metallurgical?

Mr. JOHNSON. The coal—we investigated coals in three areas; one area, some 8-plus miles south of Wainwright, and another area—two other areas northwest, one quite close to Wainwright, half a mile, another one several miles north—northeast, I should say. The coal in the area that we're suggesting as being the most promising for this type of an installation, or heat and power generation mine, the coal is classified as subbituminous C. It has a Btu value of—and an as-taken value—at about 8,300 Btu's per pound.

Senator MURKOWSKI. Is it good steam coal? Is it above average steam coal, or is it below average steam coal?

Mr. JOHNSON. Well, it's—I would say it's very good for this particular purpose. There are, of course, higher grade coals in the area.

Senator MURKOWSKI. How does it compare with coal that's being mined, say, at Usibelli, which is the only operating mine in Alaska?

Mr. JOHNSON. It's probably of a similar Btu heating grade.

Senator MURKOWSKI. OK. A similar Btu heating grade.

Mr. JOHNSON. As far as ash and sulfur comparisons, I must confess, I don't know how those directly compare. The sulfur content is down around .3 percent, which is——

Senator MURKOWSKI. Around .3 percent?

Mr. JOHNSON [continuing]. Alaskan coals are typically low in sulfur.

Senator MURKOWSKI. Lower. And east coast coal is somewhere around 5 percent, and this is .3.

Mr. JOHNSON. The ash content ranged from 5 percent to 16 percent, depending on which samples we were looking at. But, typically, at this particular location, we would be looking at an ash content in the area of 10 percent.

Senator MURKOWSKI. I think in the initial statement that I made, there was an indication that the requirement would be about 3,000 tons per year.

Mr. JOHNSON. We are thinking in terms of three different tonnage levels, depending on the phase that you consider. We have identified what could be called an interim phase, whereby heating units are put into individual homes, dual fuel furnaces, for example, or add-on furnaces, which would allow the existing heating systems in the home to be used and augmented by coal. Considering this——

Senator MURKOWSKI. You're building a power generation plant to generate power, and it's going to burn coal. And, then, is it practical to heat homes with coal, or are you better off to heat them with electricity?

Mr. JOHNSON. Well, we actually do not recommend the generation of power primarily with coal. The recommendation that we have is to produce heat with a central district heating scheme. I'd like to make an analogy. The water circulating system that many homes have in Alaska, where you have the plant in the basement, and it's circulating hot water throughout the house. A central district heating scheme is, in essence, that type of system imposed on an entire community.

Senator MURKOWSKI. So, you're not talking about any steam——

Mr. JOHNSON. We would have heating——

Senator MURKOWSKI [continuing]. Turbines in this powerplant?

Mr. JOHNSON. We are not. We're talking about low temperature——

Senator MURKOWSKI. Why aren't you?

Mr. JOHNSON [continuing]. Around 200° temperature water, and operating at about 15 psi, low pressure. This plant would be—mine mouth located a half a mile from Wainwright, right at the—exactly at the mouth of the mine. There would be water transmission lines running to the village——

Senator MURKOWSKI. What are you going to do about permafrost?

Mr. JOHNSON [continuing]. Circulating around the village——

Senator MURKOWSKI. Are you going to put it above the ground in utilidors?

Mr. JOHNSON. It can be that way, or it can be on the surface, or slightly below ground. That decision remains to be made.

Senator MURKOWSKI. Well, have you done the engineering on it?

Mr. JOHNSON. This is a feasibility study, and we've offered those two alternatives. We know that there are advantages and disadvantages to either approach. It's perhaps less costly to go above ground; it's also more objectionable from the standpoint of village travel, snow machines, walking. Above ground utilidors are not very well received.

Senator MURKOWSKI. I understand that. But my question is: The realities of putting heat underground has real problems associated with the permafrost in the Arctic and the cost of those utilidors.

Mr. JOHNSON. Those—That has been considered.

Senator MURKOWSKI. Well, I'm a little confused. I was under the impression that we were talking about a plant that was going to generate power from coal, and that within the area of the Wainwright community, at least, they were going to be able to utilize this coal in their homes. If they didn't want to, they'd have a source of power. Now, if you're going to put a plant, and it's going to cost $10 million in Wainwright, or thereabouts, you're still going to have to bring in fuel for diesel generation to gererate power, I wonder if—and I'm no engineer—if you're utilizing the capability that you've got? I recognize steam turbines cost money, but—you know— diesel generation doesn't come for nothing either.

Mr. JOHNSON. I Think I can clarify your concern there by making a few points. First of all, I very much recognize your confusion, particularly as it relates to a concept such as we're recommending, and that it's an unusual concept to be employed in the United States. It's a very common system utilized in Europe, and particularly in Scandanavia, Denmark, and also in Greenland, which, of course, is an arctic environment.

The analysis of energy requirements for Wainwright indicated that something like 90 percent of the nonvehicular energy requirements were for home heating, and less than 10 percent were for electrical energy, for lighting, and convenience appliances, and things of this nature. In other words, the lion's share of the need has to do with heating, and, therefore, we have addressed that specific item——

Senator MURKOWSKI. Well, the mayor just told us in his testimony that he heats his house 6 months of the year. If that's typical, that means that your powerplant that's going to be generating—circulating hot water is going to be operating 6 or 7—it'll obviously operate longer than that, if they have that option, but there's still a requirement of power gereration. And I thought one of our major efforts here was to try and enable the village to utilize the coal resources to offset bringing in the costly fuel, and as the village prospers, why, the power generation requirements will increase proportionately.

Mr. JOHNSON. That's quite right. We did address that.

Senator MURKOWSKI. They'll move more electricity. And——

Mr. JOHNSON. It was fully addressed in both phases of our work: Steam generation, turbine——

Senator MURKOWSKI. Why was the other dropped? Was it cost?

Mr. JOHNSON. Cost.

Senator MURKOWSKI. What would the cost be of putting in a combined plant for power gereration and heating homes?

Mr. JOHNSON. Well——

Senator MURKOWSKI. In comparison to the $10 million estimate you got on——

Mr. JOHNSON. Our conclusion is that it is uneconomic to go the other approaches as compared to the district heating scheme. Basically, you're better off staying with the existing situation of fuel oil.

Senator MURKOWSKI. You don't have a cost estimate, then, of putting in power generation?

Mr. JOHNSON. We do. I just don't——

Senator MURKOWSKI. What is it?

Mr. JOHNSON [continuing]. Happen to be able to give those to you at this moment.

Senator MURKOWSKI. Is it $20 million?

Mr. JOHNSON. I must say that—how different those estimates are compared to the selected one, how significant they are, we analyzed some eight different alternatives, and I would have to defer and come back to you on it with an answer to that, Senator.

Senator MURKOWSKI. We'd appreciate that information being submitted in the record. EPA requirements on antipollution devices would prevail on this proposed pilot plant?

Mr. JOHNSON. It's our feeling at this point in time, bearing in mind that we conducted a feasibility study, and it was not a part of our scope of work to specifically go into the environmental aspects, except for investigating the permit procedures for schedule purposes, and also to be sure that——

Senator MURKOWSKI. Has there been any effort made to do that?

Mr. JOHNSON. We have done a certain amount of work in that area, but not as a priority in this feasibility study.

Senator MURKOWSKI. Is that going to——

Mr. JOHNSON. I hasten to add, however, that we have no reason to believe that the entire system as proposed can't meet all of the standards and requirements of all of the various Federal, State, and local agencies for water, clean air, and, generally, environmental protection.

Senator **Murkowski**. Well, I'm a little confused. You're estimating a cost here of $10 million, and yet you tell us that we haven't really gone into the costs associated with antipollution devices, which, obviously, would be mandatory. There's no reason to even suggest that there would be a waiver from EPA just because it was in Wainwright, Alaska.

Mr. **Johnson**. The system, as it's been conceptually designed and estimated, meets the standards required by EPA, and all of the other agencies.

Senator **Murkowski**. So, you're telling me that for the $10 million, you can get the EPA controls that are mandatory under the law?

Mr. **Johnson**. I must make one clarification in the sense that we seem to be using a number of $10 million, and, in fact, that number is——

Senator **Murkowski**. It's the only number I've got.

Mr. **Johnson** [continuing]. Not quite right.

Senator **Murkowski**. Is that not right?

Mr. **Johnson**. We—there have been several stages of reporting on this feasibility study. First of all, there was an initial feasibility study, then there was an extended feasibility study, and we have just published the final report of that extended. There was a draft report, which has been further revised, and I think that, perhaps, is where the $10 million comes in. The final estimate produced figures, in fact, higher than that. We have——

Senator **Murkowski**. How much higher?

Mr. **Johnson** [continuing]. A price of something less—slightly less than $6 million for the mine development, and about $7.5 million for the heating and power generation complex and the district heating scheme for the entire village. So, that comes out to $13.5.

Senator **Murkowski**. So, that's about $14——

Mr. **Johnson**. Yes.

Senator **Murkowski** [continuing]. $14 million. And you have, I assume, some estimates on annual operating costs?

Mr. **Johnson**. Yes.

Senator **Murkowski**. What are they?

Mr. **Johnson**. Those are in addition. And I can pull those numbers out.

Senator **Murkowski**. Well, can you give us an idea—a guesstimate of what the annual operating costs will be?

Mr. **Johnson**. The annual operating costs, as I recall, are somewhere in the $100,000 to $200,000 range, and I'm sorry to be so vague on that. I can pull that information out for you.

Senator **Murkowski**. Does that include debt reduction?

Mr. **Johnson**. Yes, it does.

Senator **Murkowski**. Interest?

Mr. **Johnson**. Yes, it does. And the operation.

Senator **Murkowski**. Cost of mining the coal?

Mr. **Johnson**. Yes.

Senator **Murkowski**. And you said a couple of hundred thousand. I don't find that very comforting. That's kind of general.

Mr. **Johnson**. Well, let me——

Senator MURKOWSKI. I can't believe that it's that cheap on a $14 million plant. Just the arithmetic——

Mr. JOHNSON. I'm not prepared to answer that question. We're going to submit——

Senator MURKOWSKI. So, you'd withdraw that statement on the annual costs?

Mr. JOHNSON. Can I state this? The——

Senator MURKOWSKI. The labor for the mine alone would—and the operation of the boilers, just off the top of my head, it's going to cost you more than $200,000.

Mr. JOHNSON. You may be right, and I can get the information to you. Unfortunately, I do not have it on the top of my head.

Senator MURKOWSKI. OK. We'd appreciate that information, because we evidently have some rather firm figures on the costs now of $14 million.

Mr. JOHNSON. We have a very extensive cost analysis, and the—bearing in mind that I'm not the project manager on the project, nor the mining engineer, nor the district heating specialist. There are people that are better equipped to answer those questions, and I apologize for not having them here. The information is available. It would just take a few minutes for me to extract it and give it to you. I'm prepared to do that.

Senator MURKOWSKI. We're talking again about 3,000 tons of coal a year. Is that fairly firm?

Mr. JOHNSON. 4,000 tons is the final number that we've used for the district wide scheme. That's the system whereby we have the circulating water transmission system as opposed to the lesser requirement, wherein individual furnaces would be added to the homes. There's another number which drastically reduces the cost per ton, and that is 10,000 tons, anticipating the possibility that since a capital intense mine like this is very highly influenced in cost per ton because of the low volumes, exporting to neighboring communities could increase the production and bring the cost per ton far—much more into an economical range.

Senator MURKOWSKI. Well, if you're going to share this cost for 400 or 430 people, it appears it's going to be pretty high.

Mr. JOHNSON. On the 4,000 tons——

Senator MURKOWSKI. Why isn't it more feasible to bring in—to plug in the gasline 60 miles away or 90 miles away, and bring it in, and forget the coal?

Mr. JOHNSON. It may be. We haven't investigated that. That wasn't a part of our charge to investigate——

Senator MURKOWSKI. You have no opinions on that, then?

Mr. JOHNSON. I would be surprised if it could be competitive, but it has to be looked at. It's very difficult to extract numbers on—based on judgment.

Senator MURKOWSKI. Your firm isn't looking at it?

Mr. JOHNSON. No.

Senator MURKOWSKI. It would be interesting to know, and I don't know whether we have any witnesses in the room or participants that might volunteer, and it would be unqualified, but I'm inclined to think that if one examined the powerplant at Wainwright here in Fairbanks, the University of Alaska powerplant out by the university, and Eielson, all major coal fired heat and power generating plants, one might find that 3,000 tons of coal isn't very much in volume. And what I'm trying to do now is I'm going to go back and ask you some questions that were brought before the committee by the mayor of Wainwright. I would ask that you kind of respond to these as best you can, and I know that it's a little difficult to do, but Mayor Kagak felt concerned—and before I get into it. Have you met with the village council in Wainwright?

Mr. JOHNSON. Our people have, yes.

Senator MURKOWSKI. Did you participate?

Mr. JOHNSON. I didn't personally participate in the most recent meeting.

Senator MURKOWSKI. Evidently, there's some areas of concern that haven't been addressed, huh?

Mr. JOHNSON. Well, we were very concerned at the lack of active response and communication. At the last hearing, there was a very low turnout. There was very little feedback, and we've expressed that as a major point of concern in the sense that we have not been able to get a good enough reading of the public opinion in Wainwright at the time of—within the past couple of months when we were finalizing our report.

Senator MURKOWSKI. Did it occur to you that maybe they didn't want to have it happen?

Mr. JOHNSON. Well, you always have to assume that that's a possibility of—when you don't have a response, it's hard to know whether it's positive or negative. You have to assume that it may be negative. Our recommendation is for further consideration of this. That is a very major point of our recommendation, that some very sincere effort has to be made to get a feel for that, far better than what presently exists in our findings.

Senator MURKOWSKI. I assumed that this hearing was going to address a bill that the people of the North Slope Borough and the community affected, of Wainwright, were basically supportive of this proposal. That't been one of the values of the hearing to date. We've found out that isn't necessarily so. That's a surprise, but I've been surprised before, and it won't be the last time. As the mayor said, there may be a possibility that they'll change their minds, but they want some answers. I assume that you and your firm have been retained to provide those answers?

Mr. JOHNSON. We are no longer under contract to the North Slope Borough. We completed our second phase of study, and at this point in time, we don't know exactly what's going to be desired of us for continuing on this effort. At this point in time, we have completed our second phase of study, and——

Senator MURKOWSKI. So, your retainer was by the North Slope Borough——

Mr. JOHNSON. That is right.

Senator MURKOWSKI [continuing]. The city of Wainwright as a member of that borough, and that't the relationship there?

Mr. JOHNSON. That's correct. We've had——

Senator MURKOWSKI. Did you, in your study, indicate to the residents of Wainwright how large an area will be affected by the digging of a mine in the construction of a heating plant?

Mr. JOHNSON. Yes, we did, but sometimes those—it may be difficult for everyone to have a—to be able to visualize what that means. We suggested to the North Slope Borough and to the people in Wainwright that a model should be constructed to give them a physical feel for the size of the plant relative to the village, the distance from the village, perhaps a three dimensional model, which could indicate also the way the underground facility looks; how the mining cavities actually look in relationship to the whole area. I think that is a necessary thing in order to convey that information adequately.

Senator MURKOWSKI. And there were no studies commissioned to provide that model?

Mr. JOHNSON. Not at this point. It's being discussed.

Senator MURKOWSKI. Can you tell us what the area affected by the digging—how big a hole do you dig? How much land mass is the heating plant going to take?

Mr. JOHNSON. I'll describe that to you. The heating plant and the mine are, first of all, a half a mile from town. The entire footprint, if you will, of the heating plant, and the pad, and everything is about 4,000 square feet; roughly 200 by 200 feet, to give you an idea. It is immediately adjacent to an opening in the ground, which heads down at an incline of 16 percent. And about 800 feet away from this location, all underground, would be the start of the underground digging. That would be at a depth of about 120 feet. After that much incline, you would be down—you would be at the same level as a very continuous, based on our findings, 6-foot-thick coal seam, and is a very, very gentle incline. The mining method that would be employed after some 20 years, you would have an underground—I will call it a lattice. It's a mining technique called small room and pillars. Basically, you have a 16-foot-wide opening, the thickness of the coal seam, and it goes back in panels, and every 80 feet you go the other direction off of that, and essentially you wind up with something that looks like a checkerboard under there. You have to maintain vertical support, and, therefore, you do not excavate one big room; you excavate small rooms.

The entire area of this checkerboard after 20 years would extend—the dimension is about 2,000 by 1,000 feet.

Senator MURKOWSKI. Pretty small.

Mr. JOHNSON. Yes. After 20 years.

Senator MURKOWSKI. Ther would be one opening?

Mr. JOHNSON. There would be one opening. There would be a—I must say, there would be another vertical shaft right at—for ventilation and escape purposes that would be in the vicinity of where the inclined ramp comes down to the mine level.

Senator MURKOWSKI. Are there any mine wastes associated with this type of mining; liquids?

Mr. JOHNSON. There's a certain amount of liquid that would have to do with dust control and perhaps thaw down there, but not a large amount. Basically, you're confining your operation to the height of the coal seam, and virtually everything that you take out is the product, the resource itself, and very little waste.

Senator MURKOWSKI. So, there's no liquid disposal?

Mr. JOHNSON. There would be disposal associated with the ash content after burning at the plant.

Senator MURKOWSKI. Right, but no liquid disposal in the mining process. I assume that whatever water you had in the mine would be—would disperse——

Mr. JOHNSON. Most of it will come out in—as a part of the moisture content in the coal, of course, when it's burned phase.

Senator MURKOWSKI. The question that was asked is: What is excess spoil, and how is it disposed of?

Mr. JOHNSON. There is a provision as a—it would probably appear very much like the gravel pad, which would be built over the tundra to support the facilities. It would be an extension of that with those spoils, and perhaps would—as time went on at a very, very slow rate, those would be overlain with gravel and become usable surface pad. They probably wouldn't appear——

Senator MURKOWSKI. The spoils, then, is the pad for the heating plant, is that what you're saying?

Mr. JOHNSON. There is a gravel pad for the heating plant.

Senator MURKOWSKI. What is the spoils? It says "spoils." What are spoils?

Mr. JOHNSON. Well, there are spoils, of course, that evolve from running this 800-foot-long shaft down into the ground.

Senator MURKOWSKI. You get things other than coal.

Mr. JOHNSON. You go through various noncoals materials to get——

Senator MURKOWSKI. You bring those up, and you can use them for pads, or something, on the tundra, or——

Mr. JOHNSON. Right. Right. They can be directly used for constructing the pad upon which the powerplant would be going, you know. So, most of the spoils would disappear there.

Senator MURKOWSKI. OK. That's where you'd dispose of them theoretically?

Mr. JOHNSON. Yes.

Senator MURKOWSKI. But it would take you a while to—you'd dig a lot of coal before you got enough spoils to put a pad for a heating plant?

Mr. JOHNSON. The——

Senator MURKOWSKI. Yes or no. OK. I'm not going to pursue it.

Mr. JOHNSON. We would have to import—you know, bring other materials in for building that pad, but the materials that are taken out getting down to the mine level would be disposed of and—I should say—"used" in that way.

Senator MURKOWSKI. Regardless of the wind prevalances, the question of havinbg "dense, black smoke hanging over our village"; do you have any comment with regard to that?

Mr. JOHNSON. We don't see that that would be the case; a very small village, a very small amount of coal being burned, a very—quite some distance from town. I guess we tend to point to other places where this type of activity is used extensively. Denmark has to be the example I'm thinking of, whereby something like——

Senator MURKOWSKI. Well, we have within four blocks of this room the municipal utility plant for Fairbanks. It's coal fired. It provides power generation and steam for, I think, many of the downtown buildings. I don't know whether this building is on it.

Does anybody in the group know how much coal they run through that a year or would make a guess? [No comments]. I guess our——

Mr. JOHNSON. Well, I could make a comment on that. It seems to me that the 700,000 tons per year that Usibelli comes out, most of it comes up this way, isn't that correct?

Senator MURKOWSKI. It all comes up this way, but it's split between the military bases.

Will the city of Wainwright be covered by smog, like an industrial city?

Mr. JOHNSON. No. In our opinion, no, we can't imagine that possibly happening based on experience here in Fairbanks and experience in other countries where the population density is high and the consumption of coal is something like 80 percent of the total energy needs and is being used in district heating schemes like this. We're talking about a country that is probably one of the cleanest——

Senator MURKOWSKI. Would it be your recommendation that some type of an environmental study be made on the effects on the environment and the ecology associated with this plant, if it's ever built?

Mr. JOHNSON. Well, there would be a certain amount of those mandatorily required just because of the nature of the development here, and getting the various permits that are required to undertake something like this would certainly require an environmental assessment, if not something beyond that. So, those we anticipate as being a normal part of the process.

Senator MURKOWSKI. But you are not retained any more, so you have no information as to where that particular next phase of doing an environmental analysis would take place, who'd do it, and who would it be commissioned by, right?

Mr. JOHNSON. It's a matter of—for the North Slope Borough and the village of Wainwright to pursue. We have made recommendations as to what the following course of action should be. But at this point in time, you're right, we're not under contract to proceed further.

Senator MURKOWSKI. OK. I think that there will be other questions relative to this, and it appears that we've got some inconclusive relationships here between your report and the fact that you've completed your project, yet there are obviously questions in the minds of representatives of the city of Wainwright. So, that appears to be obvious.

I want to thank you, Mr. Johnson, for your testimony. I advised you that the record will be open for another 2 weeks.

[Subsequent to the hearing Mr. Johnson submitted the following information:]

arctic slope
technical services
incorporated
420 L STREET • ANCHORAGE, ALASKA 99501 • TELEPHONE (907) 276-0517

ANCHORAGE, ALASKA
BARROW, ALASKA
COPENHAGEN, DENMARK
DENVER, COLORADO
HOUSTON, TEXAS
OSLO, NORWAY
SEATTLE, WASHINGTON
WASHINGTON, D.C.

20 April 1982

The Honorable Frank Murkowski
United States Senate
Committee on Energy & Natural Resources
Subcommittee on Energy and Mineral Resources
Washington, D.C. 20510

Subject: S.2063 - Amendment to the Naval Petroleum Resources Production Act of 1976.

Field Hearing in Fairbanks, Alaska on April 8, 1982

Dear Senator Murkowski,

With reference to the subject hearing and our testimony presented at the Fairbanks hearing, we would like to submit herewith further written testimony. This testimony has specific reference to the questions which came to light during the hearing from both yourself and from Wainwright's Mayor Kagak.

The questions and concerns as expressed by Mayor Kagak were very much unexpected at this hearing. They had never been expressed during our numerous meetings and public hearings in Wainwright which were conducted specifically for that purpose. It was also our understanding that the purpose of the Fairbanks hearing was to focus on the S.2063 amendment which with passage, would simply allow villages such as Wainwright to use NPR-A coals should they ever want to without other obligations.

We therefore feel that many of the questions and concerns somewhat missed the point of the Fairbanks hearing. To clarify the record, however, we offer this letter and an attachment which paraphrases the questions raised by yourself and Mayor Kagak together with our prepared response. For some questions our response is comprehensive. For others, the matter is the subject of work yet to be accomplished in future project phases.

Please be assured of our interest and availability to work with the Village of Wainwright, the North Slope Borough, the subcommittee, yourself and other concerned parties to resolve these questions and the many remaining problems which will be encountered in a project of this magnitude.

Thank you for extending the opportunity to testify on this precedent setting matter.

Very truly yours,

ARCTIC SLOPE TECHNICAL SERVICES, INC.

L.A. Johnson, P.E.
President

LAJ/eb

Enclosure

Attachment to letter of 20 April 1982

Subject: S.2063 - Amendment to the Naval Petroleum Resources Prouction Act of 1976.

Question #1

Were you aware of the village's concerns as were today expressed by Mayor Kagak?

Answer #1

No, we were not aware of the village's concerns as expressed by Mayor Kagak. Attendency at Public meetings was poor and we received little meaningful response. We therefore recommended a public awareness campaign.

Question #2

Did you consider natural gas in your work? If not, why not?

Answer #2

We did not consider natural gas for two reasons:

- It was not included as a comparable option in our detailed scope of work.
- We were of the impression that there was no known gas closer than Barrow, and that this gas was in declining supply.

Subsequent to our initial works a further gas discovery has been made near Barrow. Consideration of this as an energy alternative should be made.

Question #3

What are the annual operating costs?

Answer #3

Annual operating costs for the mine and district heating system are as follows assuming a 4000 ton per year coal usage rate.

Mining Operation	$250,000
District Heating Operation	200,000
$450,000	

It should be noted, though, that these costs do not include capital depreciation and amortization. Our client instructed that capital would be provided as 50% grant and 50% repayable at 8% per year. On this basis capital annualized costs are as follows:

Mining Facility	$310,000
District Heating System	592,000
$902,000	

Question #4

How would you characterize the coal at Wainwright? Is it good for power/heating use?

Answer #4

The coal at Wainwright was found to be:

- Fairly moderate in heating value
- Very low in sulphur content
- High in moisture content
- High in ash content
- Zero swelling index

With the correct choice of equipment, it is quite satisfactory as a local source of energy.

Question #5

How large an area will be affected by the digging of the mine and the construction of the heating plant?

Answer #5

The surface disturbance would be between 2 and 3 acres. The heating plant itself would occupy an area 200' by 200'.

Question #6

What are "liquid mine wastes" and how will they be disposed of?

Answer #6

A glycol air mist will be used for dust control at the face of excavation in the mine. It will be diluted, collected and stored in underground mined out rooms in the forzen state.

Question #7

What is "excess spoil" and how is it disposed of?

Answer #7

Excess spoil are those cuttings which are excavated from the access tunnel which declines to the coal mine depth. These cuttings will largely be used in constructing the pad upon which the district heating plant would be built. A small amount of organic material would have to be disposed of in another approved location.

Question #8

Will there be air pollution problems created by coal smoke? Our prevailing wind is to the Northwest. However when we have a South wind or no wind at all would we have a dense black smoke hanging over our village? Will Wainwright eventually be covered by smog like a big industrial city? The study indicates that there will be no filter on the smoke stack. Will our sky be darkened by smoke or haze?

Answer #8

We foresee no particular air pollution problems created by coal smoke, nor will there be any smoke, smog or haze evident in the air around Wainwright. The particulate matter emitted by coal burning would not exceed 0.5 grams per cubic foot of exhaust gases (corrected to standard conditions) based on the quality of coal to be burned. As regards to the exhaust filters, there are multicyclone filters which are divided into sections controlled by valves in order to obtain the optimal velocity of exhaust gases and hence control emissions to within environmentally acceptable levels.

Question #9

What will be the effect on the ecology: our whales and fish and birds and other animals?

Answer #9

At this level of feasibility study a specific environmental assessment is normally not addressed, nor was it a part of this study effort. Based on our general knowledge of facilities of this kind, however, and of the many environmental requirements imposed by federal, state and local regulations, we believe all air, water and environmental quality requirements can be met. We therefore foresee no detrimental effects on bird, fish, and animal populations.

Question #10

This mine will be about 120 feet deep. Who will work down in the mine? How many of us here today would be willing to work 120 feet underground 8 hours a day?

Answer #10

To illustrate the mining situation we have proposed to our client (the North Slope Borough) that films be shown, a cut away model be presented, and selected villagers be given a tour of an operating mine. Perhaps then the village can better assess this concern.

Question #11

What other problems would arise that we do not yet anticipate? Environmental problems, ecological problems, health problems? What are the health problems connected with mining subbituminous coal in permafrost?

Answer #11

Again, it was not within the scope of our work to investigate such questions. All that can be stated in this regard then is that such questions will ultimately have to be answered to the satisfaction of the villagers. On a global basis there is much experience in coal mining which could be examined to answer these questions. Arctic coal mining has for example been underway in Norway's Svalbard (Spitzbergen Islands) at 80° North - considerably more northerly than Pt. Barrow. The villagers deserve answers to the questions, but they are beyond the scope of what we have investigated to date and we therefore cannot specifically address them herein.

Senator MURKOWSKI. Is Mr. Frank Ferguson here?

[No audible response.]

Senator MURKOWSKI. Is Mr. Don Triplehorn here?

[No audible response.]

Senator MURKOWSKI. Is there anybody that would like to testify that's in the hearing room this morning?

[No audible response.]

Senator MURKOWSKI. We are going to take a 5 minute recess to accommodate a request of Mr. Triplehorn, who is on his way, we understand. And I'd say let's be back here at—I have 11:01—about 11:11, as Brer Rabbit would say. Thank you.

[Recess taken.]

Senator MURKOWSKI. I'll call the hearing recess over, and go back to the last witness that's on the agenda. I assume we have no witnesses that want to be heard, other than our remaining witness, is that correct?

[No audible response.]

Senator MURKOWSKI. We would call on Mr. Triplehorn. Would you please approach the front of the room, Don, and we welcome you to the hearing. Mr. Don Triplehorn, a professor of geology in geophysics department, University of Alaska. Mr. Triplehorn, we have—please sit down—made a special effort to accommodate your schedule, and we're pleased that you could be here. On the other hand, we're sorry that you missed the previous testimony, because

I think it was somewhat—of paramount interest to the committee, wherein we have a position before us by the city of Wainwright that is basically opposed to the bill. So, with that information I would advise you to proceed with your testimony.

Dr. TRIPLEHORN. I have a short bit of written testimony, but basically what I would like to do is put into the record an article that was authored by Cleland Conwell and myself called "Coal for Alaska Villages," which appeared in this volume, which I think you have a copy of, and I'll secure other copies, if you need them, called "Focus on Alaska's Coal, 1980," and in that article, Cle did most of the economics and engineering, considering the relative cost primarily between fuel oil and coal. And that, I think, stands basically on its own. That our written—let's see—for a 1980 conference, so the numbers are somewhat out of date, but the general thrust of the article, I think, still holds. Why don't I go ahead and briefly read this short statement, or tell you what it has in it? Basically, I wanted to put that article in the record, and——

Senator MURKOWSKI. And it will be so noted in the record.

STATEMENT OF DR. DON M. TRIPLEHORN, PROFESSOR, GEOLOGY/GEOPHYSICS DEPARTMENT, UNIVERSITY OF ALASKA, FAIRBANKS, ALASKA

Dr. TRIPLEHORN. Yes. And then I would like to emphasize some points not—I don't think—adequately covered in that article. And one of these is that coal was once mined in many places in Alaska, including some within what is now the NPRA. Use of the coal ceased when cleaner, more convenient, and relatively low-priced oil or gas became available. And it seems logical now that local coal can—it should be used again, this time to avoid price and supply problems associated with oil.

The second point being that price may not be the only problem with oil. If some world-scale catastrophe changes the supply, such that there may be national allocation of petroleum products, in my opinion, Alaskan villages might find it difficult to find fuel at any price. In terms of national priorities, it, again, in my opinion, would be hard to justify much fuel for remote Alaskan villages. A given quantity of fuel, for example, could benefit a vastly larger number of people than, say, Kansas or Ohio, and would also help produce needed food supplies or manufactured goods in those places.

Third, local coal would be a more reliable source, because it would be less liable to interruption by bad weather or other limitations on the transportation system. Coal could be stockpiled or otherwise made readily available.

Fourth, the use of coal would provide local employment and reduce cash outflow from villages, and I think that would be a major economic advantage.

And then, finally, the quantity of coal mined and burned would be trivial in terms of the enormous resource available and would have no effect on future export potential of coal in NPRA.

And this may be pertinent to the previous testimony that I missed. Relatively simple precautions, I think, and practices could avoid any marked environmental consequences of the use of coal, again, in part, because the quantities used would be small.

And in summary, then, I would indicate that local use of coal from NPRA-4 might offer considerable advantages to several northern Alaska villages without any significant adverse effects, and I urge modification of the existing laws or regulations to permit such usage.

[The prepared statement of Dr. Triplehorn follows:]

UNIVERSITY OF ALASKA, FAIRBANKS
Fairbanks, Alaska 99701

MEMORANDUM

TO: Subcommittee on Energy and Mineral Resources of the Committee on Energy and Natural Resources of the United States Senate

FROM: Dr. Don M. Triplehorn, Professor of Geology, University of Alaska
Fairbanks, Alaska

DATE: April 8, 1982

SUBJECT: Testimony Regarding Proposed Local Use of Coal Within National Petroleum Reserve Alaska

The main part of my testimony is a copy of an article by Cleland Conwell and myself entitled "Coal for Alaska's Villages" that appeared in Focus on Alaska's Coal '80, published by the Mineral Industry Research Laboratory of the University of Alaska.

Some of the data on prices will have changed, and will continue to change, but the thrust of our article remains the same. Where coal is available nearby, it must be an attractive alternative to petroleum-based energy solely in the base of price.

Today I want to emphasize some additional points not covered in that article:

1. Coal was once mined in many places in Alaska, including some within what is now NPRA. Use of coal ceased when cleaner, more convenient, and relatively low-priced oil or gas became available. It seems logical that local coal can and should be used again, this time to avoid price and supply problems associated with oil.

2. Price may not be the only problem with oil. If some world-scale catastrophic change in supply resulted in allocation of petroleum products, Alaskan villages might find it difficult to obtain fuel at any price. In terms of national priorities it would be hard to justify much fuel for remote Alaskan villages: a given quantity of fuel could benefit a vastly larger number of people in, say, Kansas or Ohio, and would also help produce needed food supplies or manufactured goods.

3. Local coal would also be a more reliable supply because it would be less liable to interruptions by bad weather or other limitations on the transportation system. Coal could be stock-piled or otherwise be made readily available.

4. Use of local coal would provide employment and reduce cash outflow from villages. This would be a major economic advantage.

5. The quantity of coal mined and burned would be trivial in terms of the enormous resource available and would have no effect on future export potential of coal in NPRA. Relatively simple precautions and practices should avoid any marked environment consequences of coal use: again, the quantities used would be small.

In summary, local use of coal from NPRA might offer cnsiderable advantages to northern Alaska villages without any significant adverse effects. I strongly urge modification of existing laws or regulations to permit such usage.

Coal for Alaska Villages

Cleland N. Conwell
Alaska Division of Geological and Geophysical Surveys, Fairbanks
Don M. Triplehorn
Professor of Geology, Univ. of Alaska, Fairbanks

Introduction

On the world scene, wood was used for heating through the 17th century. With the advent of the industrial revolution in the 18th century, coal began to replace wood. By the late 1880s it was the dominant fuel. In the middle half of the 20th century, oil replaced coal and dominated the fuels market, almost completely replacing coal in the transportation segment of industry. Today price controls and the high price of oil have again focused attention on coal.

The use of coal in Alaska lagged behind that of the rest of the U.S. during the early part of the 20th century. By 1947 the importance of coal in the U.S. and the world was declining. In Alaska, however, coal use and production increased from 100,000 to 900,000 tons per year from 1938-67. Although the steam powered river boats and mining ventures operating around the turn of the century used wood, coal did play an important part in Alaska's development.

Coal was an important fuel in the Chignik fishery, and a coal mine operated at Chignik from 1880 until about 1914. In rural Alaska as many as 20 coal mines were in operation in 1910, and probably more than 60 coal mines have operated and closed in Alaska (Fig. 1). The village of Wainwright mined coal on the Kuk River as illustrated in Figure 2. Coal from the Meade River mine provided fuel for Barrow until 1947. Other villages mined or scavenged coal from Alaska's beaches and riverbanks until wood and coal were replaced by oil. Many individuals, particularly on the Kenai Peninsula and near Wainwright, still scavenge coal.

In Alaska's villages the need for fuel for home heating increased as the design of native homes changed from sod huts to the more conventional types with more space and less insulation. The increased demand for energy in these villages and the escalating price of oil may force a return to coal usage.

Fuel Pricing

The pricing of oil and coal is complex because both vary greatly in physical and chemical properties. The price of oil is influ-

Figure 1. A coal mine operating near Cape Lisburne in northwestern Alaska in 1904 (Collier, 1906).

Figure 2. Mining and sacking coal on the Kuk River south of Wainwright, Alaska prior to 1930 (Smith and Mertie, 1930).

enced by specific gravity, which is expressed in degrees according to an American Petroleum Institute formula. Low sulfur "sweet" oil demands a premium price over high sulfur "sour" oil. Oil is subject to both international and domestic price controls, based on an artificially controlled OPEC price. Table 1 indicates selected world oil prices as of September 1, 1980.

Crude oil was in adequate supply and at a fairly constant average price of about $3.00 per barrel during the 1960s (about $0.54/million British thermal units (MBtus)). In 1973 OPEC abruptly increased the price of crude oil from $3.01 to $5.11 and then to $11.65 per barrel. This was the beginning of a rapidly escalating price for oil and a dual pricing system in the U.S. Today's OPEC base price is $30.00 per barrel with an average price of about $32.00 per barrel ($5.52 per MBtus), an increase of over 1,000 percent in current dollars. Figure 3 shows the dramatic price increase of world oil from 1978 to date.

In general coal prices are a producer to supplier negotiated contract price per ton, but cost per ton may be misleading in evaluating coal as a fuel. On a comparative basis (dollars per Btus) the price is influenced by the rank of coal, which may vary from less than 6,000 Btus for lignite to over 14,000 Btus for a low volatile bituminous or semianthracite coal. Coal costs also vary according to producing area, from a low of about $5.00 per ton in Montana and South Dakota to a high of $56.00 per ton in Arkansas. Because lower rank coals are usually mined at lower cost, this also affects the cost per ton. For valid comparison, fuels must be evaluated on a MBtu basis.

Coal has not increased in price as dramatically as oil. In 1970 the average U.S. price of coal was about $7.00 per ton for 12,200 Btu coal ($0.28 per MBtus). The price of coal has increased in current dollars to about $30.00 per ton for an 11,000 Btu coal ($1.37 per MBtus). Figure 3 indicates the increase in price per MBtus and the widening cost gap that favors coal as a fuel.

There is only one direct comparison of oil vs. coal in Alaska. Coal is available on the retail market in Fairbanks at $46.00 per ton for an 8,000 Btu coal ($2.87 per MBtus). Heating oil is available at $1.05 per gallon ($7.01 per MBtus). Thus coal is about 60 percent less expensive than oil in Fairbanks. The fuel savings for some Alaskan villages could be much greater with a change from oil to coal, especially for those near coal fields or convenient shipping routes.

Alaska Coal Fields

Figure 4 shows the location of Alaskan coal fields. Alaska has two major coal fields, the Northern field and the Cook Inlet-Susitna field. There are lesser but still large coal fields in many other areas of the state. Coals in small fields such as

Table 1. Selected world crude prices ($/bbl)
(from Oil and Gas Journal)

Saudi light 34°	30.00
United Arab Emirates-Murban 39°	31.56
Iranian light 34°	35.00
Iraq--Basrah light 35°	31.96
Kuwait blend 31°	31.50
Algeria Saharan 44°	37.00
Nigeria--Bonny light 37°	37.00
Libyan Es Sider 37°	36.78
Indonesia--Minas 34°	31.50
Venezuela--Tia Juana 26°	29.88
Ecuador--Oriente 30°	34.08
*United Kingdom--Forties 36.5°	36.25
*Norway--Ekofish 42°	37.15
*Mexico--Isthmus 34°	34.50
Malaysia--Miri 38°	36.30
*Canadian heavy 22°	30.90
*U.S.S.R.--Romash-Kinskaya 32.4°	36.00

*Not members of the Organization of Petroleum Export Countries (OPEC) nations. Prices are F.O.B. point of loading. The weighted price of foreign oil delivered to the U.S. is about $32.00 per barrel.

The U.S. also controls the price of oil and although the present average price is about $17.00 per barrel, some U.S. oil companies demand and receive above-OPEC prices, as illustrated in table 2.

Table 2. Selected U.S. crude prices ($/bbl)

Alaska--North Slope upper tier 27°	14.27
North Slope free market 27°	20.76
Cook Inlet (Drift River) 35°	33.28
California heavy (Kern River) 13°	24.30
Wyoming Sweet	38.00
West Texas sour	36.00
West Texas intermediate	38.00
Oklahoma sweet	38.00
Gulf Coast sweet	38.00
Michigan sour	35.00

North Slope upper tier oil is price controlled. North slope free market is F.O.B. Alyeska Pump Station No. 1 (Prudhoe Bay).

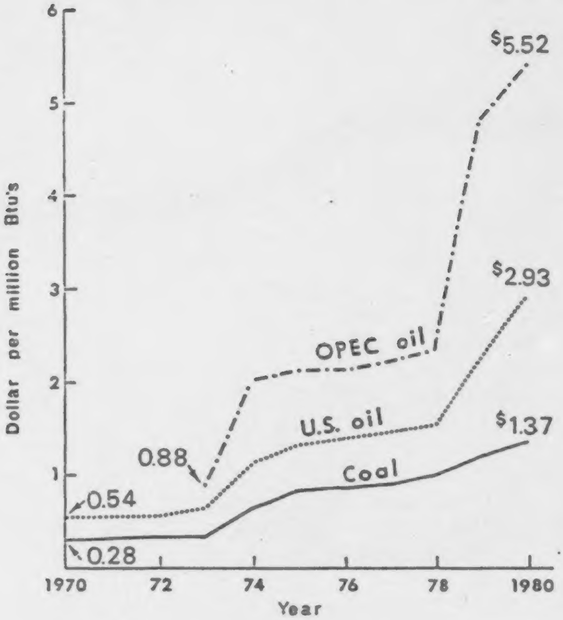
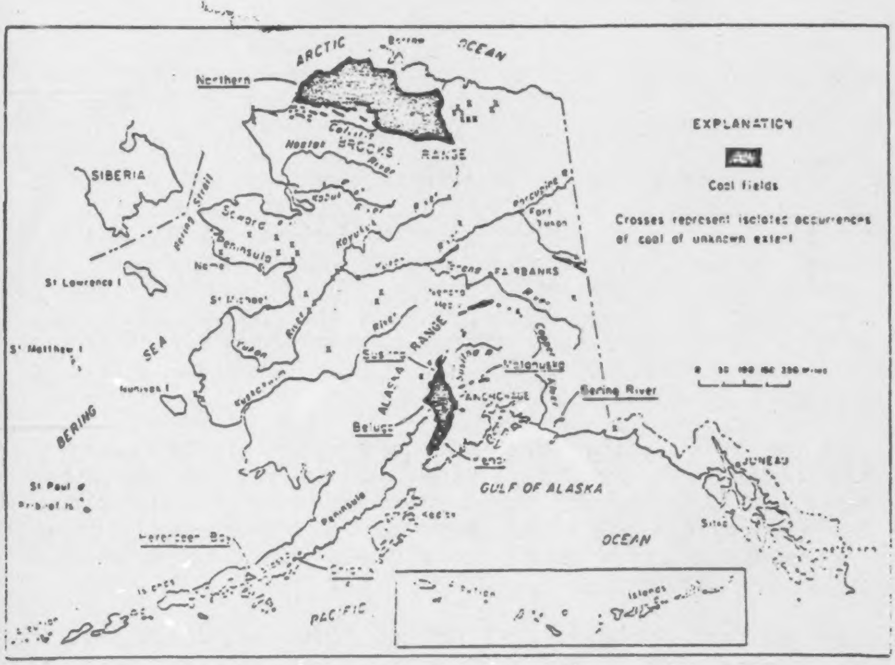


Figure 3. Cost of coal, average U.S. crude oil and OPEC crude oil in dollars per MBtu's.



ARCTIC
Barrow
OCEAN
Northern
Colville
Noatak
BROOKS
RANGE
River
EXPLANATION
Coal fields
Crosses represent isolated occurrences of coal of unknown extent
SIBERIA
Bering Strait
Seward Peninsula
Kobuk River
Koyukuk
Porcupine R.
Fort Yukon
Nome
St Lawrence I
St Michael
Yukon
Tanana
FAIRBANKS
Nenana
Susitna
ALASKA RANGE
Matanuska
Copper River
St Matthew I
SEA
Nunivak I
Kuskokwim
ANCHORAGE
Bering River
0 50 100 150 200 Miles
BERING
Beluga
Kenai
GULF OF ALASKA
JUNEAU
St Paul
Pribilof Is
Peninsula
Kodiak
Sitka
Herendeen Bay
OCEAN
Chignik
Islands
PACIFIC
Aleutian

Figure 4. Location of Alaskan coal fields.

Healy are well-known. In spite of the paucity of data, there is sufficient information to select villages as candidates for conversion from oil to coal.

Cost of Coal vs. Cost of Oil

For comparison of coal with oil, an assumption will be made that reserves are adequate in each area selected for mining, and that coal can be mined on a smallscale in an arctic region for $30.00 per ton. This cost reflects an escalation for 1981 based on extensive cost analysis by Bottge (1977) for a coal mine near Wainwright (9,350 Btu coal or $1.60 per MBtus). Dee Lane of the Rural Community Action Program provided the wholesale cost of fuel in selected rural villages. These figures have been updated to show approximate retail cost on October 7, 1980.

Estimated mining and transportation costs of coal to selected villages, and 1980 fuel oil costs are shown in Table 3. The fuel costs are compared by the common denominator of dollars per MBtu. The following areas have been selected as mine sites.

1. Wainwright for the Arctic Ocean coast
2. Cape Dyer for the Chukchi Sea
3. Unalakleet for Norton Sound
4. Herendeen Bay for the Bering Sea
5. Nulato for the Yukon River
6. Anaktuvuk Pass for the one village.

Savings made on a MBtu basis by changing from oil to coal are show in Table 3. Of course, every mine developed must be appraised on a site specific basis.

Coal is available for use in Alaskan villages, and the savings in cost by switching from oil to coal is easily demonstrated. A factor favoring local coal over imported fuel oil is physical and political availability. Many economists believe the present U.S. policy subsidizes foreign oil producers. A policy change bringing U.S. prices to the level of foreign oil would place an additional financial burden on Alaskan villages. Another consideration is the political instability of the Middle East, which could lead to rationing of petroleum products.

Oil is the primary fuel base in the transportation industry. Current technology and our dependence on air transportation may preferentially mandate oil supplies to the transportation industry. This may dictate a change to coal for heating and power generation where it is readily available. Unfortunately changes canot occur overnight.

Another argument for using coal is that mining wages are paid to local workers. The dollars for fuel would circulate within the state rather than drain "Outside" (of Alaska).

Table 3. Comparative cost of coal vs heating oil

Village	Mine	Cost of heating oil per gallon	Cost of coal delivered to village (dollars/ton)	Cost per MBtu's oil	Cost per MBtu's coal
Wainwright	Wainwright	$1.50	$30.00	$10.00	$1.67
Point Lay	Local	1.50	30.00	10.00	1.25
Point Lay	Wainwright	1.50	60.00	10.00	3.33
Point Hope	Cape Dyer	1.50	39.00	10.00	1.07
Kavalina	Cape Dyer	1.75	59.00	11.67	2.11
Kotzebue	Cape Dyer	1.35	78.00	9.00	2.78
Teller	Unalakleet	1.60	70.00	10.67	3.50
Nome	Unalakleet	1.35	60.00	9.00	3.00
Unalakleet	Unalakleet	1.50	30.00	10.00	1.50
Goodnews Bay	Herendeen Bay	1.30	90.00	8.67	3.75
Togiak	Herendeen Bay	1.50	80.00	10.00	3.33
Dillingham	Herendeen Bay	1.35	80.00	9.00	3.33
Anaktuvak Pass	30 miles north	2.50	39.00	16.67	1.95
Nulato	Nulato	1.57	30.00	10.47	1.67

Applications of Coal

Coal must compete with oil in convenience of use as well as price. The coal stove for heating and cooking is readily available, but inconvenient. An available solution may be a coal stove for heating and cooking, with a back up oil system for use when occupants are away for an extended period.

The second area of consideration is the generation of electrical power. The coal fired steam electric generator loses its competitive edge over its oil fired equivalent because of higher capital cost and environmental concerns. Good coal fired steam turbine units as small as 25 hp are available, but there is greater price escalation with decreasing size compared to diesel generators or gas turbines. Obviously each size must be evaluated separately. For example, manufacturers quote in a range of $175.00 per kw for a large gas turbine. A similar coal fired unit might run $2,000 per kw. However, if there is a use for waste heat, the economics of steam power generation rapidly change to favor coal.

Low Btu coal gas can be used in a gas turbine for power generation, and the waste heat used to produce steam for electrical power. It can also be directly used for home heating. A small city the size of Nome or Kotzebue should be considered for such an installation.

Suggested Coal Program

Alaska has a vast coal resource, but each project must be site specific and information must be developed for each mine site. Because politics and cost may dictate a return to coal, an expanded coal program is required. The state or federal Geologic Survey could expand the exploration of coal fields, particularly in areas such as Nulato, Unalakleet and Cape Dyer. Research is required for competitive utilization of coal in electrical power generation; here again the research should be site specific.

Summary

In summary, most Alaska villages could use the readily available Alaskan coal resource. Research might start with a stronger coal geology program to better understand the coal resource base, followed by site specific coal development programs to implement the conversion from oil to coal for heat and electrical power.

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by Claus-M. Naske and Don M. Triplehorn

Don Triplehorn

The Federal Government and
ALASKA'S COAL

POLITICAL BACKGROUND

President Theodore Roosevelt (1901-1909) made the conservation of natural resources a major concern of his so-called Square Deal program. Gifford Pinchot, a close friend and adviser of the President as well as the first chief forester of the United States, became the major advocate of a comprehensive national program of conservation. Roosevelt and Pinchot believed that all basic resources, such as forests, farm and range lands, and minerals and water in either private or public ownership, should be used wisely and with the least possible waste. In case of danger to the public interest, they maintained, the federal government could legally require proper utilization practices.[1]

By 1906 Pinchot, Frederick H. Newell of the United States Geological Service and other officials had formulated comprehensive land management plans which they attempted to apply to the public domain during the remainder of Roosevelt's presidency. However, Congress first had to be persuaded to revise thoroughly the public land laws originally passed to promote rapid land disposal to private individuals rather than to aid systematic development.

While no laws applied to some resources, for others existing statutes retarded rather than promoted efficient growth. In 1873, for example, Congress had enacted a coal land act which provided for such a limited maximum acreage per entry that it prevented larger and more efficient coal development. Under the provisions of this act, entry was limited to 160 acres for individuals and to 320 acres for associations. It was easy, however, to evade the law, because only the entryman supplied the facts concerning the nature of the land. Federal agents reviewed only a few of the applications to determine their validity. Under those circumstances anyone could acquire lands under a variety of laws.[2]

Congress extended the 1873 coal land laws to Alaska by 1900, but since these statutes required public surveys which did not exist in the north, the extension had not been particularly helpful. In 1904, Congress had attempted to remedy the difficulty by permitting entry of coal lands under private surveys. But since individual holdings were still restricted to an uneconomical 160 acres, the law was not really helpful.[3]

As early as 1878, Major John Wesley Powell, Chief of the Geological Survey, had proposed classifying mineral, timber, coal, and irrigable and grazing lands. The Forest Reserve Act of 1891 had set aside forest land specifically for forest production and watershed protection. And since forests included range lands, the Forest Service classified areas within the reserves as watershed, timber production, grazing, or wildlife areas.[4]

In order to clear the uncertainties and ambiguities surrounding the existing land laws, in the fall of 1903 President Roosevelt appointed a Public Lands Commission to investigate and report upon the whole question. The Commission recommended that Congress repeal or modify unsuitable laws and close existing loopholes. And although the Commission never officially completed its work, it continued as an informal group of administration leaders who supported a new set of land management principles. Pinchot and his supporters argued that the old practice of disposing of nonagricultural lands to private owners should cease, and be replaced by public ownership and management.[5]

Efficient land management, however, required an exact knowledge and careful classification of resources. The Roosevelt administration annually lobbied Congress to increase the insufficient appropriations for the Geological Survey which, for years, had struggled to carry forward a resource mapping program. With this information in hand, after 1905 the Roosevelt administration began a more systematic program of classifying all public domain resources, including water power sites, and coal, oil,

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Claus-M. Naske *is an Associate Professor of History at the University of Alaska, Fairbanks, where he specializes in the history of Alaska and northern Canada.* **Don Triplehorn** *(M.A., Indiana University; Ph.D., University of Illinois) left the Tulsa research laboratory of Sinclair Petroleum Company in 1969 to teach sedimentary geology at UAF. Since 1972 his research interests have focused on coals.*

. . . Secretary of the Interior James R. Garfield stated that "in Alaska it is possible to prevent much of the waste that has occurred in the western states."

and phosphate lands. To protect the lands under investigation from entry or sale to private parties, Secretary of the Interior James R. Garfield temporarily withdrew these areas.[4]

Each executive move to close the public domain or limit the area open to entry, however, evoked quick protests from western states where economic development was believed to depend on continued settlement and unrestricted natural resource use.

In the spring of 1906, coal laws received attention when U.S. Senator Robert LaFollette (R., Wisconsin) quoted statistics furnished by the Geological Survey on the value of coal lands being alienated from the Five Civilized Tribes. On July 26 of that year a withdrawal order closed approximately 50 million acres of coal lands which the Geological Survey had listed. On November 12, the President shocked Alaskans when he directed the Secretary of the Interior, Ethan A. Hitchcock, to withdraw from entry all valuable coal lands until they could be examined and properly classified.[6] A month later, the President explained his reasons for withdrawing the Alaskan coal lands: "The present laws put a premium on fraud because they forbid individuals and corporations from securing a sufficient quantity of land to warrant their going into the coal mining business, and yet render it easy for them to secure the extra quantity by evasion of the law."[7]

The President's withdrawal order on November 12, 1906 had halted all further location of coal claims in Alaska, and also stopped proofs and payments on existing locations. On May 16, 1907, however, the executive modified the order, allowing those claims located before November 12, 1905, and found to be legal, to proceed to patent. The President also appealed to Congress to pass a coal leasing act. He asked that the law be changed to meet the peculiar needs of Alaska. "This should be attended to at once," Roosevelt asserted, "for the present laws permit individuals to locate large areas of the public domain for speculative purposes, and cause an immense amount of trouble, fraud and litigation." And Secretary of the Interior James R. Garfield stated that "in Alaska it is possible to prevent much of the waste that has occurred in the western states."[8]

THE CUNNINGHAM CLAIMS

While the 1907 executive order had modified the 1906 withdrawal order and granted certain grandfather rights, it also had stated that those claims found to be defective or fraudulent upon investigation by the General Land Office be cancelled, particularly if evidence showed intention to consolidate claims. Approximately 900 claims in Alaska awaited investigation. Of these, 33 were known as the "Cunningham Claims," covering about 5000 acres in the Bering River coal field.[9]

Although some people thought the "Cunningham Claims" were fraudulent because of intention to consolidate, Richard A. Ballinger, head of the General Land Office, on December 26, 1907 ordered that they be processed for patenting. On January 22, 1908 Louis R. Glavis, chief of the Portland field office then investigating entries for the General Land Office, filed an adverse report on the "Cunningham Claims." The following month, Ballinger informed the Cunningham claimants that their entries had been suspended. In March, Ballinger left the General Land Office and returned to private law practice in Seattle.[10]

The May 28, 1908 Alaska Coal Act permitted consolidation of claims up to 2560 acres. The act did not contain a leasing system, and it prevented the monopolization of Alaskan coal and eliminated the use of dummy entrymen, that is, individuals who claimed lands with the intention of conveying them to someone else.[11]

As later investigations revealed, the Cunningham claimants had illegally intended to consolidate their claims before locating them. The story broke in 1909 and a bitter and lengthy controversy ensued in considering the validity of these claims. The dispute, which became known as the Ballinger-Pinchot affair, quickly assumed political overtones. Historians and others generally agree that it contributed to the subsequent political eclipse of President William Howard Taft, helped split the Republican Party, and aided Democrat Woodrow Wilson in gaining the presidency.[12] The General Land Office cancelled the "Cunningham Claims" in 1911.

THE ALASKA COAL ACT

Finally, in 1914, Congress passed an Alaskan coal leasing bill. By that time more than 1100 Alaska claims had been filed, nearly half of these had been cancelled and almost all of the others were still pending; only two had been patented. These last two were lignite deposits, one a 166-acre tract on the Kenai Peninsula, and the other a similar-sized tract on Admiralty Island. Alaska coal production in 1913 had amounted to approximately 1200 tons, none of it from the promising Bering River or Matanuska coal fields. Between 1899 and 1912, Alaskans burned 1,528,030 tons of coal, of which a mere 36,669 had been mined in Alaska.[13]

Congress had intended the 1914 Alaska Coal Act to complement the Alaska Railroad Act which had passed Congress the same year. In 1915 the President considered various alternate rail routes and settled on the so-called western one, running from Seward on tidewater through the Kenai Peninsula, the Matanuska Valley and its coal deposits, and through the Nenana lignite coal fields. The latter lay ready to end the Fairbanks fuel famine, and perhaps revive the declining placer gold mining industry. There also was the hope that coal from the Matanuska fields, already proven in steaming tests, could be shipped from Ship Creek on Cook Inlet to outside markets.[14] Construction

Olson and Spalding tunnels on Coal Creek in July 1921. (Photograph courtesy of the National Archives.)

of the Alaska Railroad began in April 1915, but the road was not finished until 1923.

In 1916, the Department of the Interior finally issued regulations to implement the coal leasing law of October 1914. Between 1907, the year after the north's coal lands were withdrawn, and 1916, when the new leasing regulations took effect, Alaskan coal production increased 19 percent, and coal imports decreased 30 percent. The import of heavy oils, including crude oil, however, increased by 158 percent during the same time span — a harbinger of the future. Coal production did increase slowly in the 1920s, mostly to supply fuel to the Alaska Railroad, Anchorage, and other communities along the line, but an export market never developed.[15]

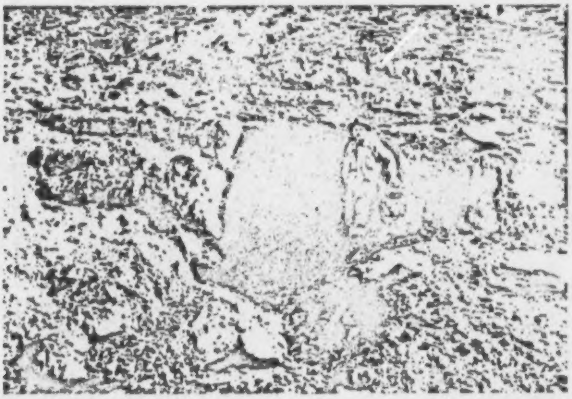
By 1928, coal production had increased to 126,000 tons annually while consumption amounted to 198,026 tons. The difference between production and consumption was imported. And not until World War II did coal production increase significantly, mainly because of defense activities. Between 1941 and 1957, coal production increased from 238,960 to 844,047 tons. Little coal was imported after the war, as the productive capacity of the mines in the postwar period far exceeded market availability.[16]

But coal mining already had begun declining in the 1940s when the Alaska Railroad, a loyal and voracious customer, began to convert its engines to diesel fuel. The Evan Jones Coal Co., one of the largest, operated in the Matanuska Valley. It depended heavily on supplying the railroad, Anchorage and the two military bases in its environs, as well as various small communities. In October 1967 the two military bases switched their power generating facilities to natural gas, and Anchorage houses also used gas heat. On March 18, 1968 the Evan Jones Coal Co. closed, and more than 100 miners lost their jobs. Except for the Usibelli coal mine at Healy in the Nenana coal fields, Alaskan coal mining had ended.[17]

Alaska still has great potential for coal development, but so far this potential has not been realized. It is historically interesting, however, to review coal use and mining in Alaska from earliest days onward.

COAL BAY NEAR PORT GRAHAM – THE BEGINNING

Although there is no written evidence, surely Alaska's natives picked up coal from river banks and sea cliffs near Cape Lisburne, at Kachemak Bay, near Tyonek in Cook Inlet, along the Yukon River and elsewhere. *(Map appears on page 22.)* The written record begins in 1789, with Captain Nathaniel Portlock's report of his 1786 discovery of coal on the Kenai Peninsula, at Coal Bay on what is now Port Graham.[18] Portlock reported



Tunnel opening of Whaler's Creek coal seam in southwestern Alaska. (Photograph from USGS Bulletin # 467; courtesy of University of Alaska Archives.)

that the coal burned well in the ship's galley. Nine years later Aleksandr Baranov, manager of the Shelikhov-Golikov Company, experimented with coal from the same locality, probably for use in smelting iron. The written record picks up again in 1851 when the Russian-American Company, faced with a precipitous decline in income from the fur trade, hired mining engineer Peter Doroshin to look for other exploitable resources in Alaska. Doroshin investigated a number of sites around Cook Inlet and the Alaska Peninsula, and also examined coal specimens from Port Moller, Cape Lisburne, Atka Island, and Chatham Strait.

Upon his return to Russia in 1853, Doroshin recommended to his employers that the Port Graham deposit be developed. In 1855, the company agreed to supply ice, fish, forest products, and coal to American settlements in California. To manage the coal venture, the Russian-American Company hired Enoch Furuhjelm, a Finnish mining engineer, and dispatched him to San Francisco to buy steam engines, pumps, and other necessary apparatus.[18]

The expedition landed at Coal Bay in July aboard the American flag vessel *Cayne*, purchased by the Company to provision all Russian trading stations in southwestern Alaska and the Kurile Islands. Furuhjelm reported that because the ship's time was limited ". . . we and our machinery, provisions, and other goods were almost thrown ashore, and even yet I cannot forget the hardships we encountered in dragging two forty-foot boilers through the breakers."[18]

The party consisted of 47 individuals, including 15 army regulars and a motley group of 25 laborers, including Russians, Finns, Creoles, Yakuts, and Kodiak (*sic*) Indians. After some intensive work and acute suffering, it was with great pride that Furuhjelm described the settlement four years later, in 1859, when ". . . the village contained a church, twenty various-sized dwellings, a large warehouse, two stables, an engine lath, a sawmill, a blacksmith shop, the mine superstructure, a kitchen, a small foundry, and some small sheds."[18]

However, as an economic venture the mine was a failure. The coal itself was good, including an upper bed 9 to 12 feet thick at a depth of only about 60 feet and consisting of 70 percent pure coal. Only one shipment of 88 tons was made to California, in 1856; after that, Californians obtained cheaper supplies from as far as England, Chile, and Australia, as well as Oregon and Vancouver Island. For a few years the mine continued to supply Russian vessels, and Furuhjelm reported 5000 tons mined by 1859. By the mid 1860s, the future of the Russian colonies was in doubt and the Company liquidated the mine in 1865. Some buildings were removed to other company posts; the remainder fell to ruins and were quickly overgrown by forest in this region of abundant rainfall.[18]

William H. Dall, then an employee of the U.S. Coast & Geodetic Survey, visited the mine in 1880. He found the tunnel full of water and its rotten timbers collapsed; he saw no coal at the surface. Dall expressed doubt about reports of a pier and extensive buildings, although these were clearly shown in a painting published in the Company annual report for 1860. He also repeated reports of shackles and chains that led to speculation that the Russians may have used convict labor.[19]

This was not the end for this enterprise, however; the mine re-opened in 1913 as the Wharf mine. That year it had the largest production in Alaska; in fact it was the only production reported, because coal land withdrawals and declining markets had essentially terminated coal mining in Alaska. The following year the mine closed for good, the owner citing federal regulations and land withdrawals.[20]

OTHER SOUTHWESTERN ALASKA DEVELOPMENTS

Coal was known to occur on Unga Island; it was examined by Doroshin in 1851. The American naturalist Dall visited there in 1865 when he was a member of the Collins Overland Telegraph Expedition.* In 1872 he commanded the *U.S.S. Humboldt*, and found the Unga coal unsatisfactory for use in the ship's galley due to its high sulfur and ash content.[19] Intermittent mining began there as early as 1896 and continued into the early 1900s. Efforts were then being made to increase production by installing new machinery and coal bunkers, but apparently these efforts were abandoned shortly after 1904.[21]

Chignik Bay was the site of the most successful early operation. In part this was due to the higher rank (greater carbonization) and quality of the Cretaceous

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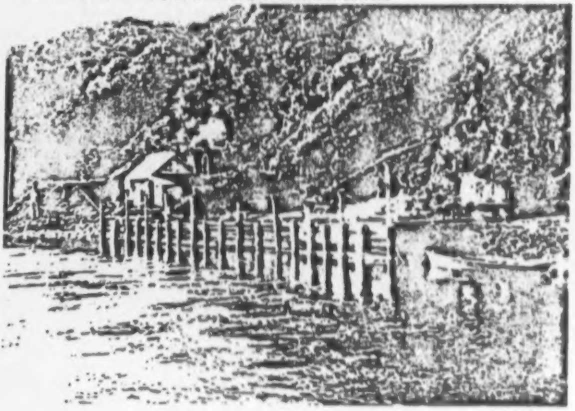
*The expedition was backed by the Western Union Telegraph Extension Company; Dall described himself as a member of the Scientific Corps of the Western Union Telegraph Expedition.

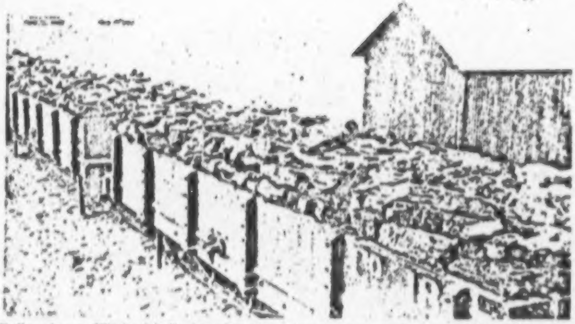
Chignik Formation coal, in comparison with the Tertiary coals mined elsewhere. Coal was discovered along the banks of the Chignik River in 1885. In 1892 the Alaska Packer's Association purchased the claim from one Robert Lee for $1765.[19] For over 20 years, the Association operated the mine to supply the company's cannery nearby. Mining ceased about 1905, probably because it was cheaper to use oil.

Herendeen Bay was the site of several attempts to mine coal between 1889 and 1904, none of them successful. Dall tried this coal for steaming purposes aboard the *U.S.S. Albatross* and found it satisfactory. A small tramway was planned to take the coal to the Pacific side at Portage Bay, but attempts were abandoned around 1905-1906 because of labor and economic difficulties, lack of markets, and loss of the seams due to faulting.

Several other mines or prospects were opened between 1900-1915 in the Cretaceous Chignik Formation at Thompson Creek, Whaler's Creek, and Hook Bay. None amounted to much, though the Thompson Creek mine had some production; in fact, it was the only mine operating in the area in 1911. The U.S. Geological Service reported the last production there in 1913.[22]

The Chignik River Coal Mine, which for many years was owned and operated by the Alaska Packer's Association to supply their nearby canneries. (Photograph from USGS Bulletin # 467; courtesy of University of Alaska Archives.)





Railroad cars filled with lignite after three years exposure to the weather at Homer. (Photograph from USGS Bulletin #277; courtesy of University of Alaska Archives.)

KACHEMAK BAY, HOMER AREA

Doroshin may have examined coals here in 1851. In 1896, Dall reported the first use by an early Kachemak Bay tourist, Thomas Hesketh, who used it for steaming aboard his yacht, the *Lancashire Witch*, in 1880. Hesketh also noted a number of coal claims west of Coal Point (Homer Spit), mostly belonging to Russian creoles from Ninilchik. Dall reported that Lieutenant R.P. Schwerin mined 200 tons in McNeil Canyon in 1891, for testing in San Francisco. This might seem suspicious since it was done on behalf of "New York parties," but it had the permission of the Secretary of the Navy.

Two San Francisco companies began mining in McNeil and Eastland canyons about 1894 and continued for three years, but they took only 650 tons out. The Southern Pacific Railroad tried the coal but rejected it because of a severe sparking tendency under forced draft, a fatal flaw in the arid southwest. As there was no market for the coal, mining was abandoned before the turn of the century. In 1904, Dall found a short wharf and bins remaining, while one tunnel was closed by a slide and the other full of water.[19]

The largest and most persistent mining efforts were undertaken at Bluff Point just west of Homer. A seven-foot seam attracted attention here as early as 1880, and an intensive mining effort was made between 1888 and 1902. Included were three tunnels, two shafts, a seven-mile railroad, and dock facilities at Coal Point. However, no export market developed and no coal was ever shipped. Dall showed pictures of railroad cars

Kenai Formation near Bluff Point. The dark band is the coal seam. (Photograph from USGS Bulletin # 277; courtesy of University of Alaska Archives.)

filled with coal which had been sitting for several years at the dock.

A somewhat more successful effort began in 1916 and coal production was small but relatively continuous until 1924. This was called the Bluff Point mine and produced a total of 20,000-25,000 tons, mostly marketed in Anchorage, Seward, and to nearby canneries. The operation failed because it did not provide reliable deliveries and users objected to the coal's high ash content. The last effort at the Bluff Point site occurred in 1946, by the Homer Coal Corporation; it was apparently short-lived. More recently small strip mines operated on the slopes above Homer from 1959 to at least 1964.[23]

SOUTHEAST ALASKA

There were a number of early attempts to mine coal in southeastern Alaska. All were small-scale and short-lived; most occurred at Kootznahoo Inlet on Admiralty Island. The coal here is of Tertiary age and of poor quality, occurs in very thin seams, and is usually steeply dipping and broken by faults. Under such conditions the only use was for local consumption; when better supplies were developed, the local efforts were abandoned before the turn of the century.

Although coal mining here never amounted to much it was sometimes colorful. Meade described the visit of the *U.S.S. Saginaw* to Kootznahoo Inlet in the summer of 1868. The following winter the same ship returned to Alaska, ran short of fuel, and found the government supply at Sitka exhausted. Meade states that ". . . the Jews of Sitka, taking advantage of the necessities of the Government, raised the price of the coal to thirty dollars a ton, which the commander of the vessel promptly refused to purchase." In a remarkable display of independence, and at some risk to his vessel and crew, he made the trip to Kootznahoo Inlet on January 13, 1869, to mine his own coal.[24] A few days later they had taken in enough coal and wood to run their ship for several weeks, and at little cost to the government.

Early records are sketchy, but in 1895 Dall found evidence of four different abandoned mines, and possibly more, in Kootznahoo Inlet. Somewhat later one of the old prospects was developed as the Harkrader mine, the most extensive coal mining effort in southeastern Alaska. This mine opened in 1928 and was worked intermittently until 1932, making a few small shipments to Juneau. Dall also describes an early attempt to mine coal at Point Gardiner, on the south end of Admiralty Island. He cited no specific dates, but noted that two tunnels had been driven on coal much broken and faulted, of inferior quality and small quantity.

There is an obscure postscript. The 1965 report of the Alaska Division of Mines and Minerals lists James Walper as a producer in southeastern Alaska but gives no location.[25] A crew of four was reported to be stripping coal; subsequent reports make no mention of this operation.

NORTHERN ALASKA

Coal beds are conspicuously exposed at many places here, particularly along the northwestern coast from southeast of Barrow to south of Cape Lisburne and along the major rivers as far east as the Colville. Although the written record is scant, there is evidence that Natives used some of these coal seams for many years. Coal was particularly useful in this treeless region where there was only driftwood brought north by ocean currents. The use of coal, however, was confined to picking up loose pieces or prying it from outcrops; no significant digging was done.

Captain Beechy observed coal seams in the Cape Beaufort area on his 1826-27 voyage. In 1904 Shrader reported that coal was first obtained for whaling ships in 1870; the practice continued for the next quarter of a century. The U.S. revenue cutter *Corwin* coaled here in 1881, giving its name to Corwin Bluff, the Corwin mine, and later to the rocks themselves, the Corwin Formation of Cretaceous age. Similarly, the Thetis mine was named for the revenue cutter of that name which visited one of the whalers' coaling localities in 1888-89.[26]

The discovery of gold at Nome in 1898 sparked interest in the Cape Lisburne region's coal. Prospectors staked many claims and undertook some small mining of the seacliffs. During 1900-1901 probably more than 1000 tons were shipped to Nome, where it brought fancy prices that quickly attracted better coal from elsewhere. Collier indicates minimal production here after 1901.

Paleozoic (Mississippian) coals of higher rank than the Cretaceous coal further south occur around Point Hope and south of Cape Lisburne. Geologists Smith and Mertie[27] reported that in 1930 a small amount of Paleozoic coal was mined at Niak, four miles south of Cape Lisburne, and at Cape Dyer, further south.

Coal was mined in the Wainwright and Kuk River area beginning in 1889. Natives used three mines on the Kuk River; not much digging was involved since the eroded edges of coal beds exposed on river banks can be picked up easily. Coal was obtained similarly along other rivers. From about 1920 into the early 1940s a mine was operated on the eastern shore of Wainwright Inlet. An executive order set aside this area for exclusive use of the Alaska Native School Service, Bureau of Education, to supply the school at Wainwright.[27] Eskimos sacked the coal and transported it in skin boats.

In the early 1940s the war brought about an acute fuel shortage at Barrow. As an emergency measure, the Alaska Native Service opened a mine on the Meade River, about 60 miles south of Barrow, and continued mining at least into the early 1960s.

The Chicago Creek mine on the Seward Peninsula was an important producer. Located on the Kugruk River near Candle, it mainly supplied local gold placer operations. This was a low-grade Tertiary lignite coal but occurred in a bed over 80 feet thick.[28] The mine opened in 1903 and, except for the war years between 1915 and 1917, it produced at least a little coal every year until the early 1940s and perhaps even later. Actually there were two mines – a second opened in 1909 – but production records apparently do not distinguish clearly between them or indicate when the second mine closed.[29]

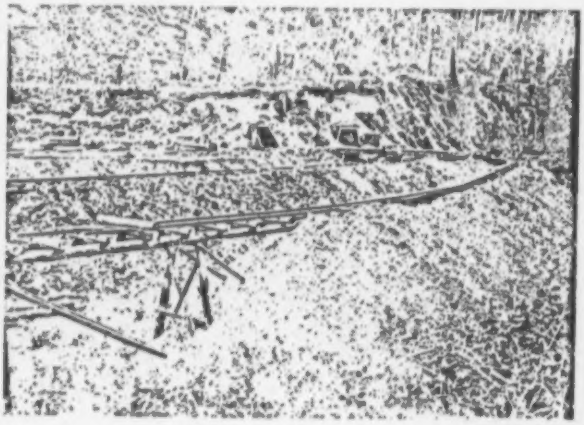
The Chicago Creek mine was the largest producer in Alaska in 1908 and there were plans to construct a mine-mouth power plant to supply electricity to the mines.[30] Even more ambitiously, in 1926 promoters proposed to construct a narrow-gauge tramway to carry the coal across the Seward Peninsula to Nome. A bill to fund this, however, was defeated in Congress in 1927.[31] The Chicago Creek mine had a long and eventful history, with almost continuous production for nearly 40 years. So far it has not received the recognition it deserves, perhaps because it was in such a remote area.

Tertiary coals were also produced in a very limited way in several other areas. The Coal Creek mine, on Norton Sound near Unalakleet, shipped to St. Michael at the mouth of the Yukon and to Nome in 1918, and continued production until at least the mid-1930s. There are also scattered reports of production in 1918, 1922, and 1931 from a mine on the Kobuk River, operated apparently to supply placer mines around the Squirrel River.[32] There is a single report of production from a mine near the mouth of the Koyuk River: it seems likely that there may have been many such small operations that were never recorded.[33]

YUKON RIVER

Gold discoveries on the upper Yukon were a great stimulus to river traffic; Collier reported nearly 100 steamers on the Yukon and its tributaries in 1898-1899. This was a golden opportunity for coal and many mines were opened in anticipation of a growing market and certain profits. There were at least 16 named mines along the Yukon and perhaps many other attempts that never progressed past the prospect stage. Collier mentions no mining on the Yukon River prior to 1897, but in that year there was a sudden flurry of activity. Examples include the Drew mine opposite Hess Creek, the Washington Creek mine near Eagle, a mine near the mouth of the Nation River, and the Pickart mine ten miles above Nulato.[34]

The rapid pace of exploration and development was followed by an abrupt decline. Most of these efforts were abandoned by 1902 and there is little record of production after 1903. Collier cites many reasons why this happened. Most of the steamers burned wood, which was cheaper, or both wood and coal. Yukon coal was sub-bituminous and often contained much ash, so the steamer operators preferred higher quality coal from British Columbia which was available at about the same price. Furthermore, many steamers converted to oil in 1902; in the next two decades much of the market for coal was lost to oil. The decisive factor at this time, however, was the rapid decline in gold mining, followed by a decrease in the number of steamers on the river from the peak of about 100 in 1899 to only 25 in 1903.[34] In short,



Coal Creek's Olson and Spalding tunnels, July 1921. (Photograph courtesy of the National Archives.)

what appeared as a very promising opportunity never really developed.

In spite of their short lives, two of the mines were noteworthy. The oldest and largest producer on the Yukon was the Drew mine, also known as the Miller or Pioneer mine. Several Tertiary coal seams occur here, with a total of 19 feet of coaly material.[34] However, there were only 38 inches of clean coal and the beds stand vertically, making them difficult to mine. Total production was only about 12,000 tons.

The Nation River, another tributary of the Yukon, had a mine which was interesting for different reasons. It also was one of the earliest opened, and the coal was highly deformed, occurring in pockets up to eight feet thick.[34] It was of good quality but had a high sulfur content, unusual for Alaskan coals. More intriguing are confirmed suggestions that it is very old coal, perhaps Devonian in age: This would place it among the oldest coals in the world. Furthermore, the location seems hard to establish; geologists working along the river within the last five years have looked for it, but without success. Perhaps this bed was an isolated occurrence on the river banks, destroyed or covered by changes in the river course.

MATANUSKA VALLEY

Beginning in about 1915 the Matanuska Valley and its coal played a central role in the history of Alaska that lasted for almost half a century, for here coal was wedded to the railroad in a bond of mutual dependence. The railroad needed coal and coal needed the railroad. As soon as possible after the government took over the railroad construction, a 38-mile spur was laid toward the Matanuska Valley, reaching Chickaloon in 1915-1916. This was the solution to avoid the exorbitant cost of imported coal and, it was hoped, provide income-producting freight in the form of coal for export. For a variety of reasons coal was never exported and the railroad became the principal customer for several decades. After the war, the railroad switched from coal to diesel engines.

At first the Navy also was expected to use Matanuska coal. In 1914, some 586 tons from Chickaloon were tested aboard the *U.S.S. Maryland* and pronounced "suitable in every respect for use in naval service."[35] One of the main arguments for developing Alaska coal was to provide a cheap and reliable supply for our Pacific fleet. With this in mind, two of the most promising coal areas were reserved for the Navy by executive order.

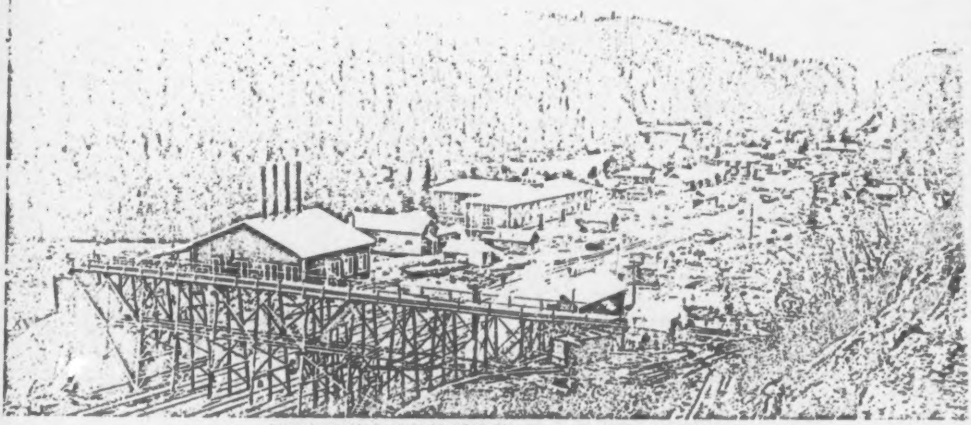
The immediate goal, however, was to obtain coal for the railroad, and the line was built to reach the nearest coal. This proved to be near the mouth of Moose Creek, which the railroad reached in July 1916. There coal was first obtained from the Doherty mine.[36] However, the coal was very ashy and the mine closed in 1917 when better coal became available from the Eska mine somewhat further up the Matanuska Valley, at Wishbone Hill. The next problem was quantity, not quality. The Eska mine operators encountered faults, fell behind in their deliveries, and apparently lacked the capital to increase production. Alarmed at the possibility of insufficient coal, the Alaska Engineering Commission, builders and operators of the railroad, purchased the Eska mine in June 1919. It was to be a temporary arrangement until private operators could provide a reliable supply.[37] Accordingly, the government-operated mine closed in October 1920, when the Evan Jones mine opened. As a security measure the Eska mine was maintained in standby condition and provided emergency supplies in 1927, 1937, and again in 1940.[38]

So many mines and operators were active in the Matanuska Valley that it is impossible to describe each one. Geologist Conwell states that 24 mines attempted to operate in 1914, stimulated by news of impending construction of the government railroad. The number declined rapidly and for many decades a few relatively large operators dominated production in the Matanuska Valley, always accompanied by the opening and closing of smaller mines.[39]

Cleaning plant at Eska coal mines. (Photo courtesy National Archives.)

Doherty's coal mine, Moose Creek. (Photo courtesy National Archives.)

Considering the time and place, Chickaloon must rank as a prime example of poor planning.



Chickaloon, Alaska, July 20, 1921. (Photo courtesy National Archives.)

A few mines merit individual description because of some unique feature. The mine near the mouth of the Chickaloon River has a special fascination. The quantity and quality of coal exposed in river bluffs here attracted attention shortly after the turn of the century; Alfred Brooks, geologist with the U.S.G.S., noted five beds between 5 and 25 feet thick. Although Tertiary in age, the rank of coals had been increased by deformation and igneous intrusions, making it some of the highest-quality coal available in Alaska, easily comparable to the older Appalachian coals.[40]

At this time, prospecting was more advanced at Chickaloon than elsewhere in the Valley. Griffith, for example, described four tunnels present in 1906. Thus it was natural that this area be selected for use by the Alaska Engineering Commission on behalf of the U.S. Navy. They took over the mine in June 1918, and commenced further exploration in 1919. By 1921 the Navy Alaskan Coal Commission townsite was cleared and an entire town constructed.[41] This included workers' cottages, a power house, hotel, office building, mine rescue hall, hospital, and school as well as extensive railroad and coal handling facilities. Then, at this incredibly late date, it was discovered that the coal exposed in the river bluffs was deceiving and that the disturbed condition of the seams, with faulting and igneous intrusions among other factors, would make the coal prohibitively expensive to mine. Therefore, operations were suspended in May 1922, and the mine and townsite prepared for abandonment the following September.[42]

Considering the time and place, Chickaloon must rank as a prime example of poor planning. Surprisingly, there were few repercussions; no investigations, no reprimands, and no newspaper headlines. Ironically the area that did so much to encourage coal development in the Matanuska Valley quickly blossomed and even more quickly died, receiving no further attention.

Another mine was important because of its size. The Evan Jones mine opened in 1920 and was the leading producer for most of the years from 1924 well into the 1950s.[43] Over these years there were fluctuations and interruptions due to mining conditions, accidents, and market demand. For example, a fire shut down the mine in 1922, market demand fluctuated wildly in the depression year of 1930, and in the worst mine accident in Alaska history, an explosion killed 14 men in 1937.[44] Even after the railroads converted to diesel power in the late 1940s and through the 1950s the market still grew as population increased and military bases were established, all requiring electrical power.

Underground mining at Evan Jones ceased in 1959; it was the most extensive in Alaska. A stripping operation continued, ultimately destroying some of the underground workings.[45] The end for the Evan Jones mine as well as all others in the Valley came with the 1967 Congressional decision to convert local military bases from coal to gas. The Evan Jones mine closed almost immediately; the last Matanuska Valley mine ceased operation in 1971 when a flood destroyed its washing plant.[46]

INTERIOR ALASKA

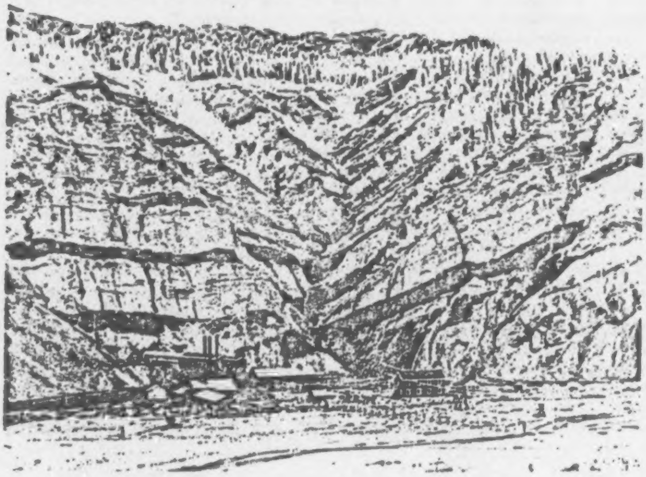
By now the pattern of coal development should be clear. First there were widely scattered small efforts in the late 1800s and early part of this century, mostly to supply local needs at mines or villages. As the railroad was constructed there were more systematic attempts to develop mines along its route. Competition for the limited market quickly caused attrition, leading to a smaller number of larger mines. An export market never materialized, and with conversion of the railroad to diesel engines, the main markets became space heating and electrical generation. The railbelt was the only place coal mining survived; elsewhere the market was lost to clean, convenient oil, even where coal was readily available and less expensive. This was also the pattern in interior Alaska.

The Short Creek mine is an example of small-scale development to meet local needs. It opened in 1916 on a tributary of the Yentna River. The Cache Creek Dredging Company operated the venture primarily to supply power for its dredge.[47] After a year, the company abandoned the first opening and started another nearer the dredge to minimize road upkeep. About a thousand tons a month were mined in 1917. Because coal mining was severely restricted at this time, it was among the three largest producers in Alaska that year.[48] There the record ends, with no official statement regarding further production, development, or abandonment. The story was similar in remote areas; Alaskans simply used coal where and when it was convenient. They were not primarily engaged in coal production, merely using it on a small scale to support their mining, fishing, or trapping enterprises. And they were not particular about keeping records.

For mining on a larger scale a railroad was necessary. Construction was planned to reach Tertiary coals of the Nenana Coal Field as quickly as possible, pushing both northward from Anchorage and south from Nenana. As the railroad progressed into the coal field a number of mines opened, each usually closing within months as better and cheaper coal sources were reached. South of Nenana the first coal outcrops were reached at mile 387 and 385, and then at mile 363, all mileages measured north from Seward.[49] These were abandoned when the thick and numerous coals near Healy became available. During 1920-1921 a number of mines opened on the west side of the Nenana River near the mouth of Healy Creek and on Lignite Creek. Two were opened by the Healy River Coal Corporation, soon to become the dominant producer in the Interior.

In 1921 the Healy River Coal Corporation began work at Suntrana Canyon four miles up Healy Creek where several high-quality coals are exposed, the thickest reaching 50 feet. In 1922 a railroad spur was completed to Suntrana. By 1927 the Suntrana mine was the sole producer in the Nenana Field, and in 1928 it produced almost half of the total coal mined in all of Alaska. By 1940 it was the largest mine in the territory.[50] Thus mining has been continuous at Healy Creek for almost 60 years, the longest for any area in Alaska. For many years the Healy Coal Corporation was the only operator, but was later joined by several others at locations further up Healy Creek.

Coal seams and mine buildings at Suntrana, near Healy, Alaska. (Photograph courtesy of the Charles Bunnell Collection, University of Alaska Archives.)



Usibelli Coal Mines Incorporated is the surviving operator, not only in Healy Creek, but since 1971 in the whole state. The company began stripping in 1944 under a U.S. Army license, one of several mines so licensed as part of a special program to increase production during the war. In 1960 Usibelli purchased the underground mine at Suntrana; because of economic conditions and a series of fires it was finally closed in 1962, thus ending over 40 years of production at this location. Stripping progressed up Healy Creek and by the late 1970s was essentially complete. Mining moved to the high divide toward Lignite Creek and, more recently, to the Poker Flat area just west of the Nenana River between the mouths of Lignite and Healy creeks.

In 1968 Golden Valley Electric Association of Fairbanks opened a 25 megawatt mine-mouth power plant at Healy. This, and the power plants at Fairbanks, Fort Wainwright, and Eielson Air Force Base, are the main customers for Healy coal. For several years there have been plans for a large addition to the GVEA plant at Healy, but in 1979 these were abandoned. *(Editor's note: This decision was discussed in the* Noted *section in* TNE *Vol. 12, No. 1.)*

Some of the smaller Interior coal mines are of historic interest, even though they were short-lived and the production relatively small. Few visitors to Mt. McKinley National Park are aware of the coal mine along the Parks Highway just east of the East Fork of the Toklat River at Milepost 42. Operated by the Alaska Road Commission until before the war, it apparently supplied fuel for the McKinley Park hotel.[51] Another mine in McKinley Park was located at Mile 341 of the railroad on the west bank of the Nenana River.[52] There is some conflict in the records, but it apparently operated sometime between 1915 and 1923. This relatively high-rank Cretaceous coal stems from the Cantwell Formation, but unfortunately the clinker fused on the boiler plates during a test at a steam plant in Nenana.

In the Broad Pass area south of the Alaska Range several small mines produced Tertiary lignites along the railroad. Of these, the Dunkle mine on Costello Creek near Colorado Station was most significant. It began about 1911, before the railroad, and supplied coal for gold mines in the area until about 1916.[53] In 1930, it was one of several localities selected for study by a special U.S. Senate committee investigating problems of the Alaska Railroad. Production was resumed about that time with a small output until its closure in 1943. In its last years it was operated by W.E. Dunkle. Tertiary coals commonly contain 20-30 percent moisture, which greatly reduces its heating value. Dunkle attempted to dry the coal before shipping it to Fairbanks; unfortunately, the experiment failed because the coal spontaneously absorbed moisture from the air.

In the early 1960s Ed Reid briefly opened a small mine on Jarvis Creek on the horth flank of the Alaska Range, just east of the Richardson Highway. This is far south of the end of the railroad at Eielson Air Force Base and the only attempt to mine in the eastern part of the several coal fields flanking the Alaska Range. The mine was unable to fulfill contracts to supply coal to Fairbanks schools by truck and closed shortly thereafter.

THE CONTINUING PATTERN

From prehistoric times to the present, coal has been locally available and locally useful in Alaska. Conceivably in the future its use may become nationally or even internationally important, as indicated by the flurries of publicity surrounding various recent coal development plans. If that happens, the historical record indicates that it will be only because of decisions made outside Alaska.

The pattern of commercial coal mining here has had a certain consistency for over 70 years. Whether by President Teddy Roosevelt or President Jimmy Carter, essential policy decisions made by national leaders in the perceived national interest have had prodigious effects on coal mining in Alaska. (Granting that the same pattern was operating in the interest of a different nation when the Russian-American Company ordered the Port Graham mine liquidated in 1865, the pattern is more than a century old.) These national decisions have affected coal production — positively or negatively — even more than have the challenges of geology or transportation.

* * * *

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Senator Murkowski. Thank you, Mr. Triplehorn. The full text of your presentation will be included in the record.

Have you had an opportunity to review any of the preparation of the Arctic Slope Technical Services with regard to this project?

Dr. Triplehorn. No, I haven't.

Senator Murkowski. Do you have any knowledge of how much coal the University of Alaska powerplant burns in a month?

Dr. Triplehorn. No, I couldn't give you the exact numbers.

Senator Murkowski. Do you have an idea?

Dr. Triplehorn. There might be others who could come closer to that.

Senator Murkowski. We tried that, and that didn't work.

Dr. Triplehorn. Yeah. How about—Gil? Do you have anything on that?

Unidentified Voice. All I can say is you'd just have to take a proportion of the 700,000 tons or use by the Interior——

Court Reporter. You'll have to repeat that.

Dr. Triplehorn. Right. The logic is the same way that I——

Senator Murkowski. About 700—you say a portion of the 700,000 tons that comes into the community?

Dr. Triplehorn. Well, not this community. That's the total production in Alaska for a number of years coming from one mine.

Senator Murkowski. From Usibelli. And it primarily comes to Fairbanks and is dissipated between Wainwright, and Eielson, and the University of Alaska.

Dr. Triplehorn. Right. And the city.

Senator Murkowski. And the city. So——

Dr. Triplehorn. I would suspect that of that 700,000, I would judge—for the university—I would judge certainly less than a 100. Would you Gil?

Unidentified Voice. I think probably less than 10 percent.

Dr. Triplehorn. Yeah, something like that. Less than 10 percent of that. That's a guess. The larger portions of that go to Wainwright and Eielson and the city. The university, I think, is a relatively small portion. I don't have the exact number.

Senator Murkowski. I was just trying to paint some kind of a comparison beteeen how much coal is 3,000 tons annually, the potential——

Dr. Triplehorn. It's not a very large quantity.

Senator Murkowski. Right. I'm inclined to agree with you. Do you know anything about the economics of this kind of a proposal which has been developed here, at least, to my knowledge now, is not a power-generating facility, but, in fact, a heating facility that's going to circulate hot water through the homes in Wainwright, and still there's going to be the dependence on power generation emanating from diesel powered, conventional reciprocal generating units? Population of 400 to 430, I think, was the testimony. Is this—What are the economics of this?

Dr. Triplehorn. I called—this may not be exactly apropos, but I called Peters Express this morning in Anchorage. And this morning, in Fairbanks, the differential between fuel oil and coal is essentially 2 to 1 on a simple Btu basis.

Senator Murkowski. Two to one.

Dr. **Triplehorn**. Two to one. And I can give you those numbers, if you want to put those in the record?

Senator **Murkowski**. We would appreciate them being submitted for the record.

Dr. **Triplehorn**. Very simply, it's this: Today you can buy in Fairbanks, delivered within the city, a minimum of two tons for $124 or $62 a ton. If you have a 500 gallon fuel oil tank, you can get fuel oil from the same company, delivered, at $1.20. And calculating those out on a Btu basis, the numbers come out to be—let's see, where did I put those down?—387 for coal versus 801 per million Btu's. Now, there are other factors you should be aware of besides the simple economics, and transportation systems, I think, would—and storage, and there are a lot of other—all right, but at any rate——

Senator **Murkowski**. So, it's 387——

Dr. **Triplehorn** [continuing]. Versus 801 today in Fairbanks.

Senator **Murkowski**. 801 on a Btu comparison?

Dr. **Triplehorn**. Right. And——

Senator **Murkowski**. And the cost per ton?

Dr. **Triplehorn**. $62 per ton with a 2-ton minimum.

Senator **Murkowski**. And the cost of oil?

Dr. **Triplehorn**. $1.20, and that's for a 500-gallon fillup.

Senator **Murkowski**. OK.

Dr. **Triplehorn**. Now, the reason I point that out that in this article—and Cleland primarily got these figures—that differential was larger at the time he wrote this. In other words, I'm saying now is that coal is—in Fairbanks—50 percent of the cost of fuel oil. At the time he wrote that, it was only 40 percent. So, there is a tendency—and I wanted to bring this up—for coal and fuel oil to approach each other, but the differential is still quite large. And one of the things that bothers me is that I think too many of us think on short-term basis. The projections are that the international price of oil is likely to stabilize after going down somewhat in the next year or so. So, one could argue, if you believe that, that the differential between oil and gas is probably not going to be as marked in the next 2 or 3 years, but I don't think we could look very well beyond that. And I, in my opinion, feel that coal is going to be a better bargain, certainly it is now, but an increasingly better bargain in, say, 5 or 10 years. The relative cost of oil has—in my opinion—got to go up relative to coal substantially, but that requires that you look at this in a longer term than, say, 2 or 3 years, something like that.

I might add one other thing, and that is that there are certainly other places besides Wainwright, and there are lots of coal deposits scattered all over Alaska. At one time, I counted some 60 named coal mines in Alaska. In other words, in 60 places in Alaska, coal had been mined to some degree. And, now, of course, we have only one coal mine. A number of those areas that had coal mines were in the north, and my overall view is a very broad one, and that is: I'm an advocate of local use of coal, wherever it may be, not only in the northern areas, but there are a number of villages that I think could benefit by the use of coal locally.

Senator **Murkowski**. Well, I would assume that you would view this proposed plant as a prototype and not necessarily a plant that had to depend on the economic viability of whether it was going to be more efficient and cost effective than current methods used to heat homes and generate electricity in that village.

Dr. **Triplehorn**. Yes. I'm an advocate of the principle. And, incidentally, you bring up something that I think has been a mistake in the past, and that is to pay much attention to efficiency. You're talking about local usage of coal that is so small compared to the volume of coal that is available that whether it required one, two, or five times as much coal really doesn't make any difference. So, efficiency of use of the material I don't think is really much of a consideration at all. I think economics probably—economics and reliability and, as I've indicated, local employment seem to me to be major factors on a broad scale that deserve consideration. Now, there is an environmental aspect, and I am not aware of the details of a proposal in this regard, but I would assume that there would be adequate safeguards to take care of most of that. In part, that should be mitigated by the fact that the usage is quite small. And, certainly, for some—probably 50 years or so, coal had been mined on the North Slope. And I don't know if there are any lasting aspects of environmental degradation related to that, but I would be willing to bet that there are not. But, certainly, some attention has got to paid to doing it right.

Senator **Murkowski**. Well, I assure you that the State department of environmental conservation, I believe, Dr. Mueller, certainly the EPA laws, would regulate any type of emissions associated with this proposed plant. I have no further questions for you. I do appreciate you making a special effort to attend.

I would like to generalize, first of all, by stating that the Chair is very pleased and wants to compliment the witnesses that have testified in establishing this record. I must admit I am a bit concerned over the realities associated with what we've learned today, because the best information that I had and that was submitted to the Committee on Energy and Mineral Resources, which resulted in this hearing being scheduled, and the accommodation extended by Senator Warner in making this date available, and also the considerable expense gone to by the Government in bringing some of you together, and certainly counsel here, was under the impression that we had some voice of unity by those that would be affected as to the merits of the bill. That, apparently, isn't the case. And that right is one that I certainly honor and understand, but I would suggest that in all reality, the questions raised today are such that the perception by the Congress is that there may be no real need for a bill at all. The question of support of this bill in view of the testimony raised is such that it's my opinion that the bill probably would not even go further in the committee, let alone go on the floor of the Congress, because I can assure you that in the environment today of Congress, there's certainly not going to be any support for this type of legislation that would be contrary to the wishes of those people in the area and those that would be affected by this proposed allowance of development of coal from the Petroleum Reserve No. 4. The input of the individual testimony in that regard is certainly paramount. If any of the questions that were proposed by the mayor of Wainwright have answered by the witnesses, why, I suppose that's good, but I am still struck by the bottom line of the testimony, which was certainly negative to proceeding with the project. Therefore, I've attempted to evaluate the current status as best I can based on my experience, and unless there is some semblance of agreement to support the project, it isn't going to go any further. The record will remain open for a period of 2 weeks, and that would be an opportunity for any further input to come in from any of the interested parties.

If there are any further witnesses that want to be heard at this time, it would be appropriate.

Yes, Mayor?

Mayor **Kagak**. Honorable Senator, I would like to——

Senator **Murkowski**. Would you approach the witness table, please?

Mayor **Kagak**. I extend my apologies to you. I——

Senator **Murkowski**. No, please, it's a pleasure to have you back up.

Mayor **Kagak**. I had a misunderstanding on this hearing, what it pertains to. And I'd like to readdress my support on this Senate bill 2063. Overall, I thought this whole hearing was on the Wainwright coal project, but at least you've got the majority of my feelings on the record.

However, after a little bit more understanding on this hearing, I do fully extend my support for what your office is doing for the North Slope Borough, and as a part of the North Slope Borough, we—I'd like to extend my appreciation on behalf of the village of Wainwright, and my misunderstanding was on this hearing from the start. I am sorry, and—but I do fully support this 2063 bill, which will open up the option for local coal conversion projects, whatever, within the North Slope Borough. Like, the mayor of Point Lay indicated to me when I talked to him about a week ago about this hearing, he indicated that the—he asked if the coal from Wainwright can be transported to Point Lay. I said go ahead, if we can do it some way. So, I didn't realize how much impact my first testimony was, but I know it will stand, too, but I do fully support you on this 2063 bill.

Senator **Murkowski**. Might I ask if—from the standpoint of the record and the testimony that you have given, Mayor, which is indicative of a unanimous position by your council that any general statement of support of the bill would be most noteworthy if it reflected a review of the subject matter and any formal action that your council would care to take. And all I can say is, in view of the fact that the record will be open for another 10 days to 2 weeks, it would enable you to do that should you so wish.

Mayor **Kagak**. Right.

Senator **Murkowski**. But I do want to emphasize again in view of the vote that was taken by your village council and your statement, which is in the record, that it would—for any major position change—it would be most appreciative for those that are going to review this record that it—your current statement of general, yet qualified, support for S. 2063 be reflected in some detail and some substantiation by your village council as represented by vote. And I think you understand the significance of the first vote you've had, and I certainly honor that vote, but I think it's representative of, certainly, an attitude that prevails. So, if you want to go back and discuss it some more, we would appreciate having whatever you would care to submit to us for the record.

Mayor **KAGAK**. Right.

Senator **MURKOWSKI**. But it's still the intention of the Chair in reviewing the testimony that you've presented that the questions and concerns that you had are not answered to your satisfaction, and until they are, you feel not inclined to support the bill which would provide for a powerplant at your village.

Mayor **KAGAK**. We would leave that up—after all, most of the answers are answered about the local problems that would create out of this powerplant, but I wish I can withdraw my statement about the vote. If I can do that, I do so.

Senator **MURKOWSKI**. You may do anything you wish, Mayor.

Mayor **KAGAK**. And I support the North Slope Borough and Ralph Anderson on his testimony, so—but this coal project has to be left open.

Senator **MURKOWSKI**. I think under the circumstances, it would be appropriate to leave the matter with the record open, and I want the hearing record to reflect that the mayor has indicated that he is giving some consideration for reviewing his position on that, free of any reflection or innuendoes from the Chair, and it's strictly upon the mayor's own personal decision to do so.

Do you have any other comments?

Mayor **KAGAK**. No more comments.

Senator **MURKOWSKI**. Thank you, Mayor. And if there are no further witnesses, the hearing record will remain open for a period of 2 weeks.

I want to thank you all for participating, and I wish you a good day and a happy Easter.

[Whereupon, at 11:40 a.m., the hearing was adjourned.]

APPENDIX

ADDITIONAL MATERIAL SUBMITTED FOR THE RECORD

City of Wainwright
BOX 9
WAINWRIGHT, ALASKA 99782
763-2815

April 14, 1982

The Honorable Senator Frank Murkowski
Subcomittee on Energy and Mineral Resources
Committee on Energy and Natural Resources
United States Senate
Room #3105
Dirksen Building
Washington, D.C.

Dear Senator Murkowski:

On behalf of the City Council and the residents of the City of Wainwright, I would like to take this opportunity to apoligize for the misunderstanding of the purpose of the Hearing that took place at the hearing in Fairbanks, Alaska on Thursday, April 8, 1982. As I indicated in my subsequent testimony, after the initial misunderstanding had been cleared up, the people of Wainwright thank you for all of your efforts in introducing and holding hearings on Senate Bill S. 2063. Now that we understand the purpose and effect of Senate Bill S. 2063, we finally, unequivocally and enthusiastically support S. 2063, and respectfully request that you and the other members of the Alaska Congressional delegation make every effort to ensure passage of S. 2063 this year.

Unfortunately, at the time of my initial testimony at the April 8, hearing, I did not know the real purpose of the hearing. Prior to my testimony, I had not received any official notification of the purpose of the hearing from the subcommittee. The only information that I received on the hearing was from the Office of the Mayor of the North Slope Borough, indicating that I should come to Fairbanks to testify at a hearing, consequently the study of coal conversion project in Wainwright. Thus, when I first testified at the hearing, I thought I was being asked to present the views of the people of Wainwright on the specific proposal for the coal mine that had been developed by ASTS.

When, during the recess of the hearing, I learned that the hearing was on S. 2063 and not the specific ASTS proposal, I asked that if I might be able to testify a second time to indicate my full support for the proposed legislation, S. 2063. Although the people of Wainwright have concerns with the coal plant proposal developed by ASTS in the feasibility study, we also believe that the use of local coal may be the way of reducing our very high fuel costs, but we also believe that feasibility study of Natural gas line from the south of Barrow field is a way reducing even more that of coal fired plant. Which in every aspects, the residents of Wainwright have full desire to see the gas line be built. We certainly know the option to use the local coal, an option that can be ensured only by the passage of S. 2063, but most heartedly, we feel that we can leave that option to our generations to come. If our concerns with aspects of a coal plant are adequately answered, as I would believe they will be, with respects of enviromental and ecological concerns.

If I had understood the purpose of the April 8 hearings from the beginning, I would have testified in full support of S. 2063, as I have during my second testimoy. The people of Wainwright appreciate the efforts that you and your staff have undertaken on our behalf and respectfully request that you continue your efforts to see that S.2063 is enacted into law in the near future, also we would be much more appreciative if the possibility of Natural gas line to the city of Wainwright is pursued by your office as an alternative. I firmly believe that the cost comparsion of the two, the coal fired plant and the Natural gas line, should be taken into close consideration as well as the aspects of the enviromental and the ecological impact in the area of Wainwright.

I hope this letter clarifies my misunderstanding at the April 8 hearing. I also respectfully request that this letter be included in the hearing record on S. 2063 in order to support other villages in the North Slope Borough that are situated in National Petroleum Reserve in Alaska. We thank you for your efforts again ask you to continued support us in things we desire and reasonably ask for. Until then, I remain same.

Respectfully,

Jacob Kagak

Jacob Kagak, Mayor
Wainwright 99782

cc; Roger Sindelar, Esquire
Counsel, Senate Committee on Energy and Natural Resources
Mr. Eugene Brower, Mayor North Slope Borough
The Honorable Senator Ted Stevens
The Honorable Representative Don Young
The Honorable Senator Frank Ferguson, Alaska District 21
The Honorable Representative Albert P. Adams, Alaska District 21
Director, Alaska Department of Natural Resources
Exective Director, Mr. Jim Ayers, RURAL Cap, Alaska
Wainwright City Council Members
Files
North Slope Borough Village Mayors, Atkasuk, Pt. Lay, Pt. Hope
Nuitsut, Barter Island, Anatuvik Pass.

Enclosure.

City of Wainwright
BOX 9
WAINWRIGHT, ALASKA 99782
763-2815

RESOLUTION 82-07

A RESOLUTION TO HAVE THE NORTH SLOPE BOROUGH EXPLORE OR STUDY THE FEASIBILITY OF A NATURAL GAS LINE FROM SOUTH OF BARROW TO THE CITY OF WAINWRIGHT.

WHEREAS, the North Slope Borough has completed the feasibility study of coal use in the City of Wainwright as a economical project and;

WHEREAS, the citizens of Wainwright are not much aware of the envorimental and ecological impact that the creation of Central Heating System would have and;

WHEREAS, The Mayor of Wainwright presented testimonies concerning important factors that would bring hardship to the citizens and the natural habitat, such as wildlife and marine life in the vicinicty of Wainwright and;

WHEREAS, the feasibility study done on the Central Heating System in the village of Wainwright only explores the economical stand point of view and not the envorimental and ecological impact it would have and;

WHEREAS, the testimony of Mayor of Wainwright indicated the desites of residents of Wainright to have natural gas line to the City of Wainwright and;

WHEREAS, the cost comparision of the two would be of a greater difference and importance to the government of North Slope Borough and;

WHEREAS, the residents of Wainwright are aware the construction of Central Heating System would cost more than the construction of Natural gas line and;

WHEREAS, the reisdents of Wainwright are aware of Heating system lines that would be placed inside the village of Wainwright and zigzaging to and fro and;

WHEREAS, the distribution lines would hinder the traversing of snowmachines here and to within the Village of Wainwright and put more hardship on the hunters within the village and;

WHEREAS, the Mayor of Wainwright, at the time of the hearing did not know that the hearing held in Fairbanks on April 8, 1982 was on Senate Bill 2063 and;

RESOLUTION 82-07
CITY OF WAINWRIGHT
SUPPORTING PASSAGE OF SENATE BILL 2063 AND POSSIBLITY OF NATURAL GAS LINE TO THE CITY OF WAINWRIGHT, ALASKA 99782

WHEREAS, the office of the Mayor of North Slope Borough only informed the Mayor of Wainwright, that the Hearing was on Coal Conversion Project in order to get it funded through the United States Congress and;

WHEREAS, the Council of Wainwright only supports the passage of Senate Bill 2063 in order to help other villages obtain permits of Coal use within the North SlopBorough and situated within the National Petroleum Reserve in Alaska and;

WHEREAS, the Council of Wainwright and the residents of Wainwright are fully aware of high cost of heating presently use in village of Wainwright and;

WHEREAS, the government of North Slope Borough can study the possibility of Natural gas line to the Village of Wainwright and;

WHEREAS, the residents of Wainwright with concurence of the City Council are aware of other alternatives other than the present study that could more benefit the North Slope Borough and;

WHEREAS, Natural gas burns cleaner and more economical than the proposed coal fired generatine system and less impact of the gas line would have on our envoriment and ecology and;

WHEREAS, Natural gas line would have less impact on our tundra, our Caribou, waterfowl, fish and whale than coal fired generating system and;

WHEREAS, the cost of maintaining of Central Heating system of Coal Fired Plant would not benefit the parties concerned and;

NOW THEREFORE BE T RESOLVED that the City Council of Wainwright supports the passage of Senate Bill 2063 and;

BE IT FURTHER RESOLVED that the City Council of Wainwright of the City of Wainwright respectfully request that the Alaska Congressional Delegation take all steps necessary to ensure timely passage of this legislation by the 2nd Session of the 97th Congress of the United States and;

RESOLUTION 82-07
CITY OF WAINWRIGHT
SUPPORTING PASSAGE OF SENATE BILL 2063 AND POSSIBILITY OF NATURAL GAS LINE TO THE CITY OF WAINWRIGHT, ALASKA 99782

BE IT FURTHER RESOLVED that the City Council of Wainwright of the City of Wainwright respectfully request the Alaska Congressional Delegation take all steps necessary to explore the possibility and feasibility of a Natural gas line to the City of Wainwright as the residents with full concurence of the City Council desires.

DATE INTRODUCED: April 13, 1982
DATE ADOPTED: April 13, 1982

APPROVED:

Jacob Kagak
Mayor

Frances Hopson
Vice Mayor

Peter Panik
Council Member

Ida Panik
Council Member

Rossman Peetook
Council Member

Billy Nashoalook
Council Member

Frank Bester Sr./Not present
Council Member

ATTESTED:

Charlie L. Dolison
City Clerk

VAN NESS, FELDMAN, SUTCLIFFE, CURTIS & LEVENBERG
A PROFESSIONAL CORPORATION
1050 THOMAS JEFFERSON STREET, N. W.
SEVENTH FLOOR
WASHINGTON, D. C. 20007
(202) 331-9400

S. LYNN SUTCLIFFE
HOWARD J. FELDMAN
WILLIAM J. VAN NESS, JR.
BEN YAMAGATA
ROBERT G. SZABO
GRENVILLE GARSIDE
GERRY LEVENBERG, P. C.
ROSS D. AIN
ALAN L. MINTZ
ROBERT R. NORDHAUS
CHARLES B. CURTIS
GARY L. FONTANA

GARY D. BACHMAN
R. KEITH GUTHRIE
PETER D. DICKSON
JEFFREY S. CHRISTIE
NANCY E. WILLIAMS
ADAM WENNER
RICHARD D. RATHVON
ELLEN D. SWYLER
SUSAN TOMASKY
W. ROBERT GRAY

April 20, 1982

The Honorable Frank Murkowski
United States Senate
Room 2104
Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Murkowski:

On behalf of the North Slope Borough and myself, I apologize for the unfortunate events that occurred at the April 8 hearing in Fairbanks, Alaska, on S. 2063, a bill to permit use of local coal by villages in the National Petroleum Reserve-Alaska for heat and generation of electricity. I am hopeful that the confusion that led to the problems at the hearing has been eliminated and that the misunderstandings created at the hearing may now be rectified.

Before addressing the apparent confusion at the April 8 hearing, I would like to take this opportunity to thank you and your staff for all of your support and assistance in this matter. The people of the North Slope Borough and I appreciate all of the efforts that have been devoted to this legislation and the Fairbanks hearing by you, your staff and the staff of the Subcommittee on Energy and Mineral Resources.

After the April 8 hearing on S. 2063 in Fairbanks, I talked at considerable length with Mr. Jacob Kagak, the Mayor of the village of Wainwright, to determine the basis for his initial testimony at the hearing. From that discussion, it now appears that Mr. Kagak did not fully understand the purpose of the hearing. Unfortunately, Mr. Kagak thought that he had been asked to testify on the specific coal project proposal prepared by Arctic Slope Technical Services rather than the provisions of S. 2063. When he realized that the hearing was only on legislation to authorize the use of local coal by the village of Wainwright, he expressed his complete support for the legislation. Indeed, since the Fairbanks hearing, Mr. Kagak and the people of the village of Wainwright have expressed to me and to others their support for S. 2063, recognizing that the legislation will enable them to fully consider the prospects of utilizing local deposits of coal to satisfy their space heating and electrical generation needs. I understand that the City Council of Wainwright will soon consider a resolution expressing its support for S. 2063.

At the time of the hearing, however, the people of Wainwright did have concerns about particular aspects of the specific proposal set forth in the Arctic Slope Technical Services feasibility study. Many of these concerns were raised by Mr. Kagak in his initial testimony before the Subcommittee. Obviously, these concerns must be addressed and satisfied prior to the approval of any project to utilize local coal for the village. However, if Mr. Kagak had understood the specific purpose for the hearing, *i.e.*, to consider the provisions of S. 2063, he would have given his support to that legislation, as he did in his second round of testimony before the Subcommittee.

As counsel to the North Slope Borough, the primary sponsor for the legislation that you have introduced on behalf of the people of Wainwright, I bear substantial responsibility for the confusion and misunderstandings that culminated in Mr. Kagak's testimony at the April 8 hearing. Unfortunately, I had assumed, quite incorrectly, that Mr. Kagak and the people of Wainwright understood the purpose for the Fairbanks hearings and would address the pending legislation in their testimony. Since I did not anticipate this confusion or the testimony to be presented, the problems created by Mr. Kagak's testimony were not averted. Again, I apologize for any inconvenience that the events of April 8 may have caused you, your staff or the staff of the Subcommittee.

In this regard, I would like to take this opportunity to commend your staff and the staff of the Subcommittee for the professional manner in which they have handled all aspects of this matter. Both prior to the hearing and throughout the hearing, they have provided considerable assistance to us in this matter, assistance for which we are very grateful. They certainly bear no responsibility for the unfortunate events at the April 8 hearing.

It is my hope that the true position of the people of the village of Wainwright on this matter has been or will be conveyed to you. I understand that the people of Wainwright are quite enthusiastic about the prospects of utilizing local deposits of coal to replace expensive fuel oil to produce electricity and space heating in their village. After the full support of the people of Wainwright has been conveyed to you, I am hopeful that the hearing record will provide a strong impetus for early enactment of S. 2063.

Thank you again for your assistance and encouragement on this legislation. If you have any questions concerning this matter, please do not hesitate to call upon me.

Sincerely,

Alan L. Mintz

Alan L. Mintz

cc: Mayor Eugene Brower
Roger Sindelar, Esq.
Joyce Bamberger, Esq.

COAL FOR ALASKA VILLAGES

Cleland N. Conwell[1] and Don M. Triplehorn[2]

INTRODUCTION

On the world scene, wood was used for heating through the 17th century. With the advent of the industrial revolution in the 18th century, coal began to replace wood. By the late 1980s, it was the dominant fuel. In the middle half of the 20th century, oil replaced coal and dominated the fuels market, almost completely replacing coal in the transportation segment of industry. Today price controls and the high price of oil have again focused attention on coal.

The use of coal in Alaska lagged behind that of the rest of the U.S. during the early part of the 20th century. By 1947 the importance of coal in the U.S. and the world was declining. In Alaska, however, coal use and production increased from 100,000 to 900,000 tons per year from 1938-67. Although the steam-powered river boats and mining ventures operating around the turn of century used wood, coal did play an important part in Alaska's development.

Coal was an important fuel in the Chignik fishery, and a coal mine operated at Chignik from 1880 until about 1914. In rural Alaska as many as 20 coal mines were in operation in 1910 and probably more than 60 coal mines have operated and closed in Alaska (fig. 1). The village of Wainwright mined coal on the Kuk River as illustrated in figure 2. Coal from the Mead River mine provided fuel for Barrow until 1947. Other villages mined or scavenged coal from Alaska's beaches and riverbanks until wood and coal were replaced by oil. Many individuals, particularly on the Kenai Peninsula and near Wainwright, still scavenge coal.

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[1] Alaska Division of Geological and Geophysical Surveys, Fairbanks, Alaska.
[2] Professor of Geology, University of Alaska, Fairbanks, Alaska.

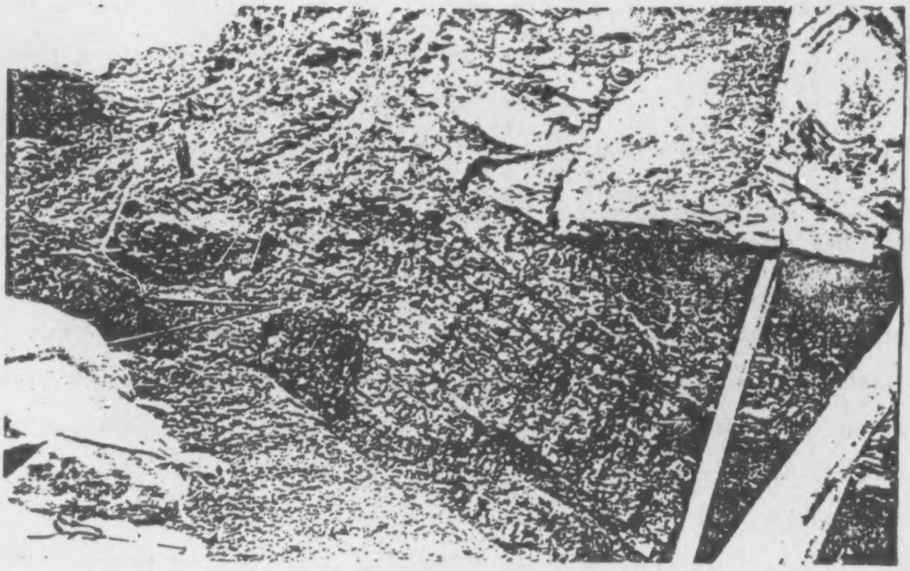


Figure 1. A coal mine operating near Cape Lisburne in northwestern Alaska in 1904 (Collier, 1906).

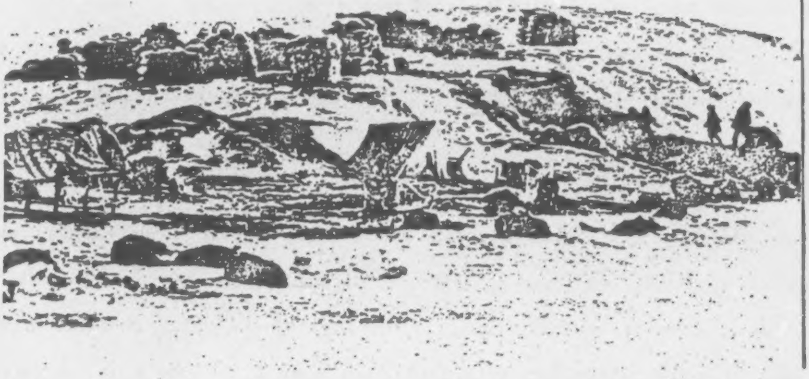


Figure 2. Mining and sacking coal on the Kuk River south of Wainwright, Alaska prior to 1930 (Smith and Mertie, 1930).

In Alaska's villages the need for fuel for home heating increased as the design of Native homes changed from sod huts to the more conventional types with more space and less insulation. The increased demand for energy in these villages and the escalating price of oil may force a return to coal useage.

FUEL PRICING

The pricing of oil and coal is complex because both vary greatly in physical and chemical properties. The price of oil is influenced by specific gravity, which is expressed in degrees according to an American Petroleum Institute formula. Low sulfur 'sweet' oil demands a premium price over high sulfur 'sour' oil. Oil is subject to both international and domestic price controls based on an artifically controlled OPEC price. Table 1 indicates selected world oil prices as of September 1, 1980.

Crude oil was in adequate supply and at a fairly constant average price of about $3.00 per barrel during the 1960's [about $0.54/million British thermal units (MBtus)]. In 1973 OPEC abruptly increased the price of crude oil from $3.01 to $5.11 and then to $11.65 per barrel. This was the beginning of a rapidly escalating price for oil and a dual pricing system in the U.S. Today's OPEC base price is $30.00 per barrel with an average price of about $32.00 per barrel ($5.52 per MBtu's), an increase of over 1,000 percent in current dollars. Figure 3 shows the dramatic price increase of world oil from 1978 to date.

In general coal prices are a producer- to supplier-negotiated contract price per ton, but cost per ton may be misleading in evaluating coal as a fuel. On a comparative basis (dollars per MBtu's) the price is influenced by the rank of coal, which may vary from less than 6,000 Btu's for lignite to over 14,000 Btu's for a low volatile bituminous or semianthracite coal. Coal

Table 1. Selected world crude prices ($/bbl)
(from Oil and Gas Journal)

Saudi light 34°	30.00
United Arab Emirates-Murban 39°	31.56
Iranian light 34°	35.00
Iraq--Basrah light 35°	31.96
Kuwait blend 31°	31.50
Algeria Saharan 44°	37.00
Nigeria--Bonny light 37°	37.00
Libyan Es Sider 37°	36.78
Indonesia--Minas 34°	31.50
Venezuela--Tia Juana 26°	29.88
Ecuador--Oriente 30°	34.08
*United Kingdom--Forties 36.5°	36.25
*Norway—Ekofish 42°	37.15
*Mexico--Isthmus 34°	34.50
Malaysia--Miri 38°	36.30
*Canadian heavy 22°	30.90
*U.S.S.R.--Romash-Kinskaya 32.4°	36.00

*Not members of the Organization of Petroleum Export Countries (OPEC) nations. Prices are F.O.B. point of loading. The weighted price of foreign oil delivered to the U.S. is about $32.00 per barrel.

The U.S. also controls the price of oil and although the present average price is about $17.00 per barrel, some U.S. oil companies demand and receive above-OPEC prices, as illustrated in table 2.

costs also vary according to producing area, from a low of about $5.00 per ton in Montana and South Dakota to a high of $56.00 per ton in Arkansas. Because lower rank coals are usually mined at lower cost, this also affects the cost per ton. For valid comparison, fuels must be evaluated on a MBtu basis.

Coal has not increased in price as dramatically as oil. In 1970 the average U.S. price of coal was about $7.00 per ton for 12,200 Btu coal ($0.28 per MBtu's). The price of coal has increased in current dollars to about $30.00 per ton for an 11,000 Btu coal ($1.37 per MBtu's). Figure 3 indicates the increase in price per MBtu's and the widening gap of cost that favors coal as a fuel.

Table 2. Selected U.S. crude prices ($/bbl)

Alaska--North Slope upper tier 27°	14.27
North Slope free market 27°	20.76
Cook Inlet (Drift River) 35°	33.28
California heavy (Kern River) 13°	24.30
Wyoming Sweet	38.00
West Texas sour	36.00
West Texas intermediate	38.00
Oklahoma sweet	38.00
Gulf Coast sweet	38.00
Michigan sour	35.00

North Slope upper tier oil is price controlled. North slope free market is F.O.B. Alyeska Pump Station No. 1 (Prudhoe Bay).

There is only one direct comparison of oil vs coal in Alaska. Coal is available on the retail market in Fairbanks at $46.00 per ton for an 8,000 Btu coal ($2.87 per MBtu's). Heating oil is available at $1.05 per gallon ($7.01 per MBtu's). Thus coal is about 60 percent less expensive than oil in Fairbanks. The fuel savings for some Alaska villages could be much greater with a change from oil to coal, especially for those near coal fields or convenient shipping routes.

ALASKA COAL FIELDS

Figure 4 shows the location of Alaska coal fields. Alaska has two major coal fields, the Northern field and the Cook Inlet-Susitna field. There are lesser but still large coal fields in many other areas of the state. Coals in small fields such as Healy are well known. In spite of the paucity of data, there is sufficient information to select villages as candidates for conversion from oil to coal.

COST OF COAL VS OIL

For comparison of coal with oil, an assumption will be made that reserves are adequate in each area selected for mining and that coal can be mined on a

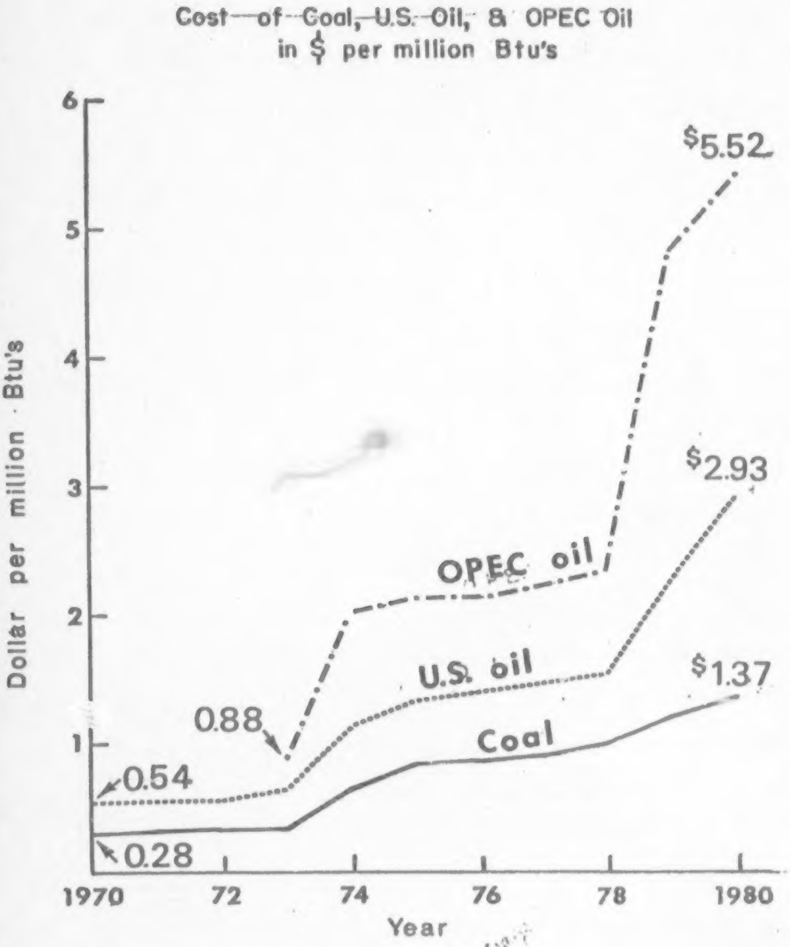


Fig. 3. Cost of coal, average U.S. crude oil ~~[illegible]~~, and OPEC crude oil in dollars per ~~million~~ MBtu's.

small scale in an arctic region for $30.00 per ton. This cost reflects an escalation for 1981 based on extensive cost analysis by Bottge (1977) for a coal mine near Wainwright (9,350 Btu coal or $1.60 per MBtu's). Dee Lane of the Rural Community Action Program provided the wholesale cost of fuel in selected rural villages. These figures have been updated to show approximate retail cost on October 7, 1980.

Estimated mining and transportation costs of coal to selected villages and 1980 fuel oil costs are shown in table 3. The fuel costs are compared by the common denominator of dollars per MBtu. The following areas have been selected as mine sites.

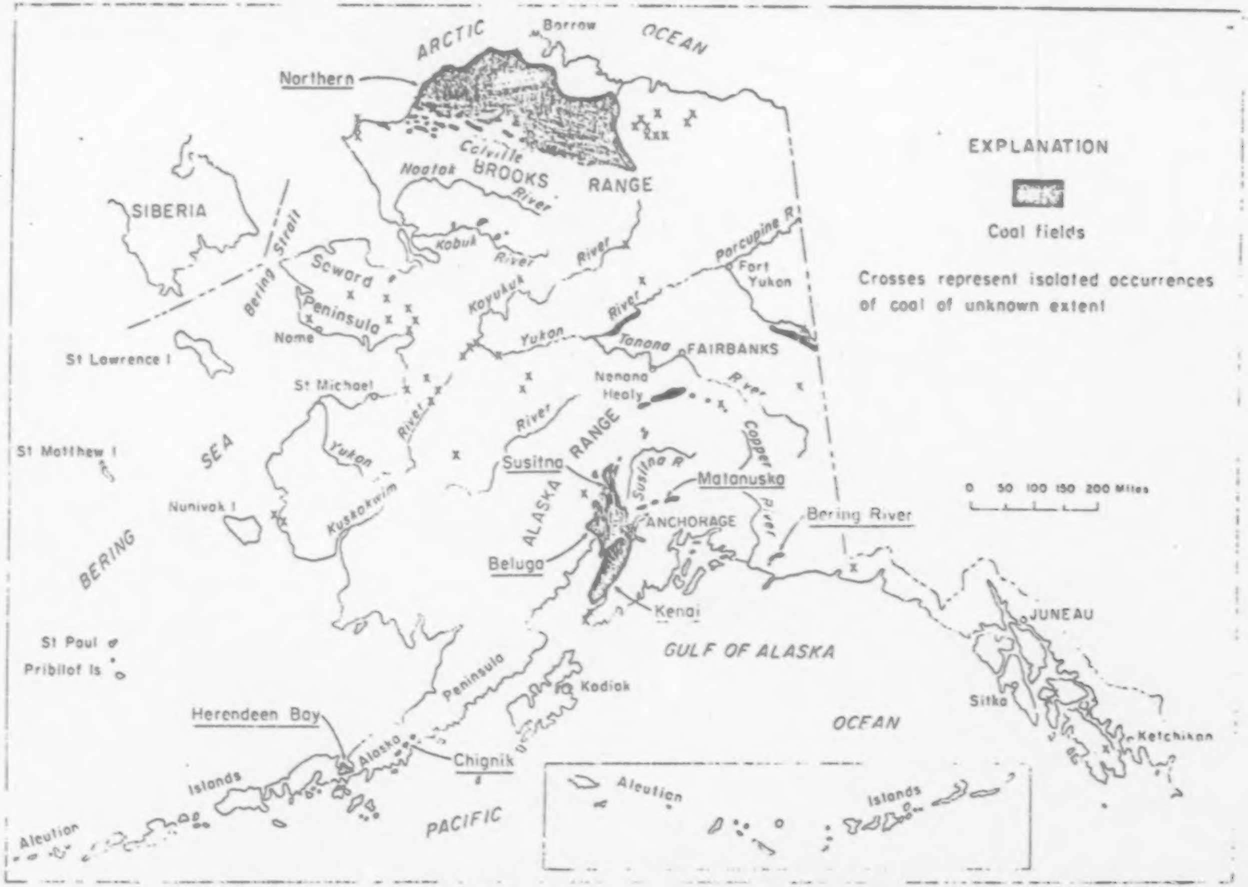
1. Wainwright for the Arctic Ocean coast,
2. Cape Dyer for the Chukchi Sea,
3. Unalakleet for Norton Sound,
4. Herendeen Bay for the Bering Sea,
5. Nulato for the Yukon River, and
6. Anaktuvuk Pass for the one village.

Savings made on a MBtu basis by changing from oil to coal are shown in table 3. Of course, every mine developed must be appraised on a site-specific basis.

Coal is available for use in Alaska villages, and the savings in cost by switching from oil to coal is easily demonstrated. A factor favoring local coal over imported fuel oil is physical and political availability. Many economists believe the present U.S. policy subsidizes the foreign oil producers. A policy change bringing U.S. prices to the level of foreign oil would place an additional financial burden on Alaska villages. Another consideration is the political instability of the Middle East which could lead to rationing of petroleum products.

Table 3. Comparative cost of coal vs heating oil

Village	Mine	Cost of heating oil per gallon	Cost of coal delivered to village (dollars/ton)	Cost per MBtu's oil	Cost per MBtu's coal
Wainwright	Wainwright	$1.50	$30.00	$10.00	$1.67
Point Lay	Local	1.50	30.00	10.00	1.25
Point Lay	Wainwright	1.50	60.00	10.00	3.33
Point Hope	Cape Dyer	1.50	39.00	10.00	1.07
Kavalina	Cape Dyer	1.75	59.00	11.67	2.11
Kotzebue	Cape Dyer	1.35	78.00	9.00	2.78
Teller	Unalakleet	1.60	70.00	10.67	3.50
Nome	Unalakleet	1.35	60.00	9.00	3.00
Unalakleet	Unalakleet	1.50	30.00	10.00	1.50
Goodnews Bay	Herendeen Bay	1.30	90.00	8.67	3.75
Togiak	Herendeen Bay	1.50	80.00	10.00	3.33
Dillingham	Herendeen Bay	1.35	80.00	9.00	3.33
Anaktuvak Pass	30 miles north	2.50	39.00	16.67	1.95
Nulato	Nulato	1.57	30.00	10.47	1.67


ARCTIC
OCEAN
Borrow
Northern
Colville
BROOKS
RANGE
Noatak
River
Kobuk
River
Koyukuk
River
Porcupine R
Fort
Yukon
SIBERIA
Bering
Strait
Seward
Peninsula
Nome
St Lawrence I
St Michael
Yukon
River
Tanana
FAIRBANKS
Nenana
Healy
River
Copper
River
ALASKA
RANGE
Susitna
Susitna R
Matanuska
ANCHORAGE
Bering River
Beluga
Kenai
St Matthew I
SEA
Nunivak I
Yukon
Kuskokwim
BERING
St Paul
Pribilof Is
GULF OF ALASKA
JUNEAU
Sitka
Ketchikan
Kodiak
Peninsula
Alaska
Herendeen Bay
Chignik
Islands
Aleutian
PACIFIC
OCEAN
Aleutian
Islands
EXPLANATION
Coal fields
Crosses represent isolated occurrences of coal of unknown extent
0 50 100 150 200 Miles

Fig~~ure~~ 4. Location of Alaskan Coal Fields.

Oil is the primary fuel base in the transportation industry. Current technology and our dependence on air transportation may preferentially mandate oil supplies to the transportation industry. This may dictate a change to coal for heating and power generation where it is readily available. Unfortunately changes cannot occur overnight.

Another argument for using coal is that mining wages are paid to local workers. The dollars for fuel would circulate within the state rather than drain Outside.

APPLICATIONS OF COAL

Coal must compete with oil in convenience of use as well as price. The coal stove for heating and cooking is readily available, but inconvenient. An available solution may be a coal stove for heating and cooking with a back-up oil system for use when occupants are away for an extended period.

The second area of consideration is the generation of electrical power. The coal-fired steam electric generator loses its competitive edge over its oil-fired equivalent because of higher capital cost and environmental concerns. Good coal-fired steam turbine units as small as 25 hp are available but there is greater price escalation with decreasing size than with corresponding diesel generators or larger gas turbines. Obviously each size must be evaluated separately. For example, manufacturers quote in a range of $175.00 per kw for a large gas turbine. A similar coal-fired unit might run $2,000 per kw. However, if there is a use for waste heat, the economics of steam power generation rapidly change to favor coal.

Low Btu coal gas can be used in a gas turbine for power generation, and the waste heat used to produce steam for electrical power. It can also be directly used for home heating. A village the size of Nome or Kotzebue should be considered for such an installation.

SUGGESTED COAL PROGRAM

Alaska has a vast coal resource, but each project must be site specific and information must be developed for each mine site. Because politics and cost may dictate a return to coal, an expanded coal program is required. The state or federal geologic survey could expand the exploration of coal fields, particularly in areas such as Nulato, Unalakleet, and Cape Dyer. Research is required for competitive utilization of coal in electrical power generation; here again the research should be site specific.

SUMMARY

In summary, most Alaska villages could use the readily available coal resource. Research might start with a stronger coal-geology program to better understand the coal resource base followed by site-specific coal development programs to implement the conversion from oil to coal for heat and electrical power.

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Oil and Gas Journal, 1980, Statistics: Oil and Gas Jour., v. 78, no. 39, p. 158.

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I.

Economics of Alaska Mine Development and Intrastate Transportation

INTRODUCTION

The exact amount of Alaska coal is currently unknown and a subject of much debate. Undiscovered Alaska coal resources are currently estimated at 1.85 to 5 trillion short tons (Alaska Division of Energy and Power Development 1977), while identified Alaska coal resources are estimated at only 130,126 million short tons (Barnes 1967). The wide range of estimates for Alaska coal resources is primarily due to the lack of geological data as almost all Alaska coal fields have not been thoroughly investigated or developed. Estimated identified coal resources of Alaska are shown by coal field and coal type in Table I-1 and Table I-2 respectively. A more extensive desc[illegible] of Alaska's coal resources is provided in Appendix A.

TABLE I-1
ESTIMATED COAL RESOURCES OF ALASKA
BY COAL FIELD
(millions of short tons)

Coal Field	Bituminous	Subbituminous and Lignite	Total
Northern Alaska	19,292	100,905	120,19
Nenana	—	6,938	6,93
Jarvis Creek	—	77	7
Broad Pass	—	64	6
Matanuska	137	—	13
Susitna (Beluga)	—	2,395	2,39
Kenai (Homer Dist.)	—	318	31
Total Identified Coal Resources	19,429	110,697	130,12

SOURCE: Barnes 1967

TABLE I-2
ESTIMATED COAL RESOURCES OF ALASKA
(millions of short tons)

	Measured	Indicated	Inferred	Total
Anthracite	Trace	—	—	Trace
Bituminous	6.6	890.4	18,532.2	19,429.2
Subbituminous & Lignite	861.6	7,028.8	102,806.4	110,696.8
Total Identified Coal Resources	868.2	7,919.2	121,338.0	130,126.0

SOURCE: Barnes 1967

FIGURE I-1
THE THREE COAL AREAS UNDER ASSESSMENT

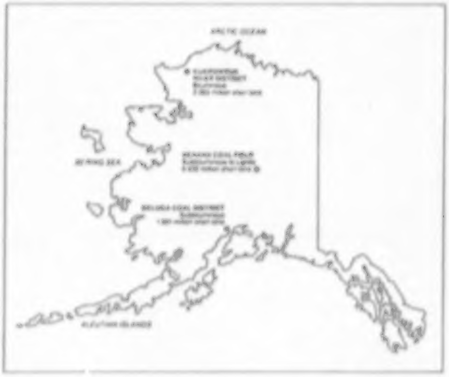
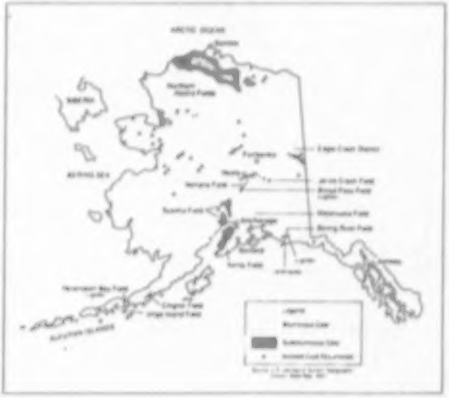

ARCTIC OCEAN
BERING SEA
ALEUTIAN ISLANDS

FIGURE I-2
COAL RESOURCES OF ALASKA


ARCTIC OCEAN
Northern Alaska Fields
BERING SEA
Nenana Field
Susitna Field
Jarvis Creek Field
Broad Pass Field
Matanuska Field
Bering River Field
ALEUTIAN ISLANDS

Although coal exists throughout the entire state of Alaska, this study only investigates the development of coal resources from the three specific coal-bearing areas mentioned in the introduction: (1) the Beluga coal district in the Susitna coal field, (2) the Usibelli Mine in the Nenana coal field, and (3) the Kukpowruk River district in the northern coal field. Figure I-1 illustrates the locations of the three coal-bearing areas assessed in this study and Figure I-2 shows all the major coal deposits in Alaska. The three coal areas were selected for investigation to represent the wide range of environmental, transportation, mining and socioeconomic issues that would be encountered in developing any of Alaska's coal resources. The intent of the study is to estimate the current prices of three specific Alaska coals and determine if these specific Alaska coals are or may become competitive in Pacific Rim steam coal markets.

Alaska coal selling price estimates free-on-board (FOB) at Alaskan ports, which are navigable year-round, are determined here for coal from the Kukpowruk River district, the Usibelli Mine in the Nenana field and the Beluga coal district. The selling price estimates are based on (1) projected mining costs, (2) mine-support infrastructure costs, (3) inland transportation costs, and (4) port costs. The selling price estimates in this chapter combined with marine transportation costs developed in Chapter II will serve as the basis for comparing Alaska coal prices with other coal supply prices in the specific market areas identified in Chapter III.

MINE DEVELOPMENT

BELUGA COAL DISTRICT

The Beluga Coal District is part of the Susitna Coal Field and is located in south central Alaska approximately 60 miles west of Anchorage in the Kenai Peninsula Borough. Figure I-3 shows a 50 foot coal outcrop in the Beluga Coal District. Although the Beluga Coal District is relatively close to Anchorage, Alaska's largest population center, the area is largely undeveloped and lacks the necessary transportation and support facilities required by a major coal mine's labor force. However, due to the potential minesite's close proximity to tidewater and existing utility generation and transmission facilities, it is generally considered a likely candidate for near-term development. The characteristics of Beluga coal are:

Rank of Coal: Subbitiminous
Total Identified Resources (million short tons): 1,801
Thickness of Beds: Ranges widely from a few inches to 50 feet
Moisture: 11%-30%
Volatile Matter: 27.8%-30.1%
Fixed Carbon: 25.8%-34.6%
Ash: 8%-30.5%
Sulfur: .2%
Heating Value (BTU/lb): 6,290-8,890

FIGURE I-3
A FIFTY FOOT THICK COAL OUTCROP IN
THE BELUGA COAL DISTRICT

Placer Amex Inc., a Beluga leaseholder and experienced mining company, has performed extensive geological exploration in this area and has formulated a realistic development plan. This report bases its estimated selling prices on a Placer Amex development proposal.

According to the Placer Amex mine development proposal, coal averaging 7,500 BTU/lb could be produced at an estimated selling price at the mine of $15.00 to $22.50 per ton or $1.00 to 1.50 per million BTU (Placer Amex Inc. 1980). The proposed mining operation would require an annual production level of at least 5 million tons to provide sufficient revenues to support the necessary auxiliary facilities and infrastructure for mine employees working in an undeveloped area.

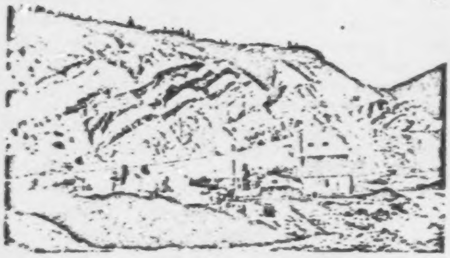
Run-of-mine coal would be crushed, screened and stockpiled for delivery. The stockpiled coal could be hauled to tidewater by tractor trailers until market demands increased to 2 to 3 million tons/year and therefore justified the construction of a railroad. The mining and inland transportation systems would utilize conventional technologies.

NENANA COAL FIELD

The Nenana Coal Field (Usibelli Mine) is the only major producing coal field in Alaska and extends for about 80 miles along the north flank of the Alaska Range. The Usibelli mine, located in the Nenana field near Healy, is the only mine currently producing coal in the Nenana field. Figure I-4 shows some coal seams exposed in a bluff near the Usibelli mine. The Nenana field's coal characteristics are:

Rank of Coal: Subbituminous to Lignite
Total Identified Resources (million short tons): 6,938
Thickness of Beds: Ranges widely from a few inches to 60 feet
Moisture: 11.7%-32.7%
Volatile Matter: 31.2%-42.9%
Fixed Carbon: 22.7%-36.6%
Ash: 3.3%-15.9%
Sulfur: 0.1%-.4%
Heating Value (BTU/lb): 6,320-10,385

FIGURE I-4
EXPOSED COAL SEAMS IN A BLUFF NEAR THE
USIBELLI MINE



The selling price estimates for Nenana coal are based on data provided in 1980 by Joseph Usibelli, president of Usibelli Mines, Inc. These estimated selling prices represent a minimum price for Nenana coal at the Usibelli mine at indicated production levels. The extrapolation of Usibelli coal selling prices to other Nenana coals is certainly not a totally precise estimating method. However, Usibelli prices at the 4.1 million tons/yr production level, which would require the expansion of the mine and the establishment of new draglines and support facilities similar to new mines in other areas of the Nenana coal field, provide a good price estimate for coal from other promising minesites in the Nenana coal field.

The Usibelli mine currently sells coal at an approximate FOB mine price of $18.00 per ton or $1.13 per million BTU. The coal, which has an average heating value of 8,000 BTU/lb., is distributed and consumed entirely within the state of Alaska. At the current production rate of 750,000 tons/yr the mine is operating below capacity and could increase production to 2.1 million tons per year with existing capital equipment. The average selling price FOB mine at a 2.1 million ton per year production rate is estimated by Usibelli Mines, Inc. at $16.00 to $18.00 per ton or $1.00 to $1.13 per million BTU.

However, Usibelli Mine, Inc. also estimates that any production above the 2.1 million ton per year rate, which would require additional mining equipment and new coal leases but would permit more efficient operation of support services such as maintenance, engineering, clerical and sales, will decrease average FOB mine selling prices to $14.00 to $16.00 per ton or $.88 to $1.00 per million BTU due to economies of scale in the mine's operation. Table I-3 summarizes Nenana FOB mine coal prices based on Usibelli FOB mine estimates at increased production levels which would produce coal in excess of current demand.

KUKPOWRUK RIVER DISTRICT

The Kukpowruk River District is located in a wilderness area at the northern edge of the Arctic foothills, fourteen miles east of the Chukchi Sea coast. This part of Alaska, due to its harsh climate, delicate environment and remoteness, creates a number of environmental, social, economic, legal and technical constraints to development. This section incorporates reasonable estimates of all the costs associated with these constraints.

However, in considering the development plan proposed for the Kukpowruk River district, it must be remembered that the economic and social costs of solutions to technological, environmental, or legal problems may prevent all mining in northern Alaska. A recent example of the possible increased costs, which may be incurred on projects in northern Alaska, is the Trans-Alaska Pipeline System (TAPS), built by the Alyeska Pipeline Service Company. The TAPS cost increases of over 100% during its three years of construction serve as a warning to any development project in northern Alaska to expect not only unbudgeted costs but also large cost increases in almost all budgeted expenses.

TABLE I-3
NENANA COAL PRICES
(FOB Mine)

Production Level	$/Ton	$/Million BTU
2.1 million tons/yr*	16.00-18.00	1.00-1.13
4.1 million tons/yr	14.00-16.00	.88-1.00

*maximum production [illegible] existing equipment

SOURCE: Reference 1980.

The Kukpowruk River district represents the northwest area of the North Slope of Alaska. Its coals are of high quality and coal-bearing rocks are exposed along the lower twenty-five miles of the Kukpowruk River and also underlie a small area seventy miles above the mouth of the river. The field's coal characteristics are:

Rank of Coal: Bituminous
Total Estimated Resources (million short tons): 3,065
Thickness of Beds: 1½-13 feet
Moisture: 0.8%-9.9%
Volatile Matter: 31.4%-35.6%
Fixed Carbon: 52.6%-56.1%
Ash: 2.5%-15.0%
Sulfur: 0.2%-.3%
Heating Value (BTU/lb): 11,910-12,880

An August 1977 Kaiser Engineers, Inc. report performed for the Bureau of Mines provides the basis for Kukpowruk coal selling price estimates projected in this report. The Kaiser engineers designed a hypothetical mine using three different mining methods: (1) draglines, (2) shovels and trucks, and (3) combinations of draglines and shovels and trucks. The dragline mining method was the most economical, so only those costs are incorporated into this report.

The equipment requirements and mining costs were es-

The Resource Conservation and Recovery Act[34] places "cradle to grave" controls over the generation, transportation and disposal of hazardous and other solid wastes. The Act establishes a permit system and authorizes criteria for identifying hazardous wastes based on ignitability, corrosiveness, reactivity, and toxicity. In addition to establishing a system for classifying industrial wastes presumed to be hazardous, recently proposed toxicity criteria would classify as a hazardous waste any substance for which a primary drinking water standard has been established if its concentration is ten times greater than the drinking water standard.[35] Like the CAA and CWA, RCRA contemplates that states will assume permit and program enforcement responsibilities. In the event that wastes are generated, stored, treated, transported or disposed of by mine or synthetic fuel plant operators and constitute "hazardous wastes," such operators must comply with RCRA record keeping, reporting, labeling, use and handling requirements and obtain RCRA permits.

The Toxic Substances Control Act (TSCA) directs EPA to identify and regulate the manufacture, processing, distribution, use, and disposal of hazardous chemical substances and mixtures.[36] Synthetic liquids are generally considered to have a high potential for containing toxic or carcinogenic constituents. TSCA requires a developer to notify EPA or a participating state ninety days prior to production of a new chemical or product and submit environmental and health data. If EPA determines that introduction of the product would pose an unreasonable risk, it could restrict or prohibit production, require future testing or regulate the handling, transportation, and end-use of the product.

APPLICATION OF ENVIRONMENTAL REQUIREMENTS

Despite the very best mining technology and pollution control efforts, strip mining and synthetic fuel plant operation of any significant size will have some adverse health and environmental effects. Degradation of the air and water supplies and the disposal of huge amounts of wastes that contain traces of toxic metals represent well-recognized environmental impacts. Development of the Beluga and Kukpowruk River District fields may also cause more extensive socio-economic impacts on nearby residents and communities than expansion of the Usibelli Mines in the Nenana field. Housing, schools, police and fire protection, water and sewer systems, roads, utility services and other community service needs can be expected to result from any moderately sized development activity.

Several issues involving compliance with NEPA would be presented by development of Alaskan coal fields. Since federal permits, licenses and approvals may be required, a determination of whether an EIS will also be required must be made at the outset. In the event development of study area sites, including expansion of the existing Usibelli Mine near Healy, Alaska, requires issuance of an EPA administered NPDES permit, EPA may be designated as the lead federal agency to undertake preparation of an EIS. Other affected federal agencies would assume cooperating roles in support of EPA's lead role. This chapter does not attempt to address all NEPA-related questions; rather, it is intended to identify general problem areas that can be expected to arise under NEPA.

Assuming an EIS is to be prepared, its scope and range of alternatives to be considered must be defined. The Usibelli mine in the Nenana field near Healy, Alaska is the only producer of coal in Alaska. The Usibelli mine has the potential for expanding production. Expansion of a previously approved existing use may not constitute a major federal action significantly affecting the quality of the human environment. However, the requirement of an EIS is likely to rest on the magnitude and nature of expanded mining activity at the existing Usibelli Mine site and whether mining methods go beyond existing activities or technologies.

The use of new synthetic fuels technologies, such as solvent refined coal processes and coal gasification, would likely cause new environmental impacts not currently associated with the existing Usibelli Mine operation. For example, in situ conversion processes could adversely impact ground water and drinking water supplies (salinity, organics, and trace metals) and large volumes of toxic or hazardous wastes could require costly disposal techniques. Such impacts may require the preparation of an EIS.

A decision to proceed with new development of the Beluga, Nenana and Kukpowruk area fields will likely trigger NEPA's EIS requirements. The need to prepare an EIS will require a fundamental decision regarding the scope of an EIS. A "site-specific" EIS would address only the environmental impact resulting from individual federal actions. A "comprehensive" EIS would examine a proposal's entire system impact. In the absence of existing facilities and given the scale of proposed development at the Beluga and Kukpowruk area sites, a "comprehensive" and perhaps a "regional" EIS might examine mining operation, synthetic fuels technology, overland and marine transportation routes, port development, community-related impacts, associated facilities, and powerplant development.

Recently approved and mandatory Council on Environmental Quality (CEQ) regulations implementing NEPA set forth regulations designed to streamline the EIS process.[37] The CEQ regulations provide for the preparation of a single, lead agency EIS and utilization of a draft EIS as an initial project planning document. To avoid delays and insure that planning and decision-making reflect environmental values, the regulations require integrating NEPA's requirements with other planning, environmental review and consultation procedures required by law so that all such procedures run concurrently rather than consecutively.[38]

Any plan to develop or convert Alaska coal resources must not only comply with existing regulatory requirements but accept certain risks associated with the impact of future promulgated environmental requirements. Since future requirements of synfuel technologies are difficult to predict, it is possible that facilities may be required to alter their design and plant operation to comply with new regulations. A recent DOE analysis has concluded that despite reclamation, hazardous waste, and solid waste manage-associated facil[illegible]development, and community development, could be proposed and considered together in the creation of district wide CZM programs and consolidated in any required NEPA EIS for the district CZM program. Integration of CZMA and State of Alaska program development requirements with CEQ requirements could facilitate later site-specific industry planning and public participation to ensure that all major federal and state environmental and regulatory requirements are fully and simultaneously considered early in state and local land use decision-making.

Initiation of early NEPA and coal development system planning with district CZM program development could result in a district intergovernmental programmatic or comprehensive EIS that could avoid replaying major federal regulatory reviews and serve as the principal environmental planning effort and record for later federal and state decision-making concerning all coal-related development.

Another important issue likely to influence Alaska coal development is the creation of "boom towns," the need for new and permanent communities, and socio-economic impacts on existing communities. Mitigation of the impacts of coastal and upland coal development in Alaska could be funded through a variety of mechanisms. Coastal Energy Impact Program (CEIP) assistance is currently available under CZMA Section 308 for coastal communities affected by energy development.[59] Congress recently extended CZMA program authorization to permit CEIP assistance for States adversely affected by coal transportation, transfer, and storage.[60] Additional federal assistance for socio-economic impacts to local communities may be available from the Economic Development Administration of the Department of Commerce and the Department of Agriculture under Title VI of the Industrial and Powerplant Fuel Use Act.[61] In the absence of federal efforts, assistance for mitigating local community and environmental impacts may be secured through imposition of state or local severance or conversion taxes.

OTHER FACTORS AFFECTING ALASKA COAL DEVELOPMENT

A variety of regulatory and non-regulatory factors may also influence Alaska coal development. The Industrial and Powerplant Fuel Use Act (FUA)[62] would appear to provide an incentive to Alaska coal development by prohibiting the use of oil or natural gas in new utility generation facilities and certain new industrial boilers. Existing facilities capable of using coal may also be required to use coal under the FUA. Coal is only one of many fuels which can be used to comply with the Act. In addition to encouraging coal gas use by classifying coal as an alternate fuel the FUA provides temporary exemptions from FUA prohibitions for facilities which plan to use coal-derived alternate fuel (e.g., coal derived methanol).[63] FUA prohibitions and exemptions apply to both new and existing major fuel burning installations. FUA prohibitions and exemptions, however, apply only to new powerplants in Alaska.[64]

Despite enactment of FUA prohibitions, the current availability of natural gas and ability of firms to obtain exemptions from the Act have not prompted contiguous United States or Alaskan utilities to convert to coal. Additional federal incentives have been proposed for utilities without sufficient financial ability to convert to coal. Such utilities would be eligible for grants to construct coal handling facilities, pollution control equipment and other changes to permit burning of coal.[65] Additional incentives to greater coal use may be generated by Executive Order 12217 which mandates federal facilities compliance with FUA construction and conversion requirements.[66]

Title I of the recently enacted Energy Security Act[67] provides incentives that may contribute to Alaska coal development. The Act establishes a goal of producing an equivalent of at least 500,000 barrels of crude oil per day (BPD) of synthetic fuel by 1987 and 2,000,000 BPD of synthetic fuel by 1992. Under Phase I of the program the Board is authorized to award $20 billion to private firms to construct synthetic fuels facilities. To encourage private capital investment in the domestic production of synthetic fuels, Title I authorizes creation of an Energy Security Corporation (ESC) to provide price guarantees, direct loans, loan guarantees up to 75 percent of project costs, purchase agreements, and joint ventures with the ESC. Financial assistance would be available for: production facilities; land and mineral rights required for use in connection with a plant; equipment used to extract minerals for conversion to synthetic fuels from either a mine located next to a plant or located elsewhere if no other source of the mineral for the plant were available; and transportation facilities, electric powerplants, transmission lines or other equipment necessary for the project. The Act makes assistance available to any person, state, Indian tribal organization, including Alaska Native villages and corporations.

Another key factor likely to influence development of Alaska coal resources would be enacted of the proposed Energy Mobilization Board (EMB).[68] Under Senate Bill 1308, designation of a priority energy project would require affected federal agencies to give the Board a decision scheduled related to the project. States would be required to provide similar information for required state and local actions. Within sixty days after priority project designation, the Board would publish a decision scheduled setting deadlines for agency action. In the event a federal, state or local agency failed to make a decision under such deadlines, the Board would be empowered to make such a decision applying the applicable law. The Board would also be authorized to waive certain federal, state and local regulations enacted or promulgated after construction of a priority project was begun. Court challenges to Board actions would be required to be consolidated and heard before a specialized Temporary Emergency Court of Appeals. At this writing, S. 1308 has not been enacted by Congress.

CONCLUSIONS

1. Assuming that lands can be acquired, no single federal or state regulatory requirement standing alone appears to

preclude development of selected study sites.

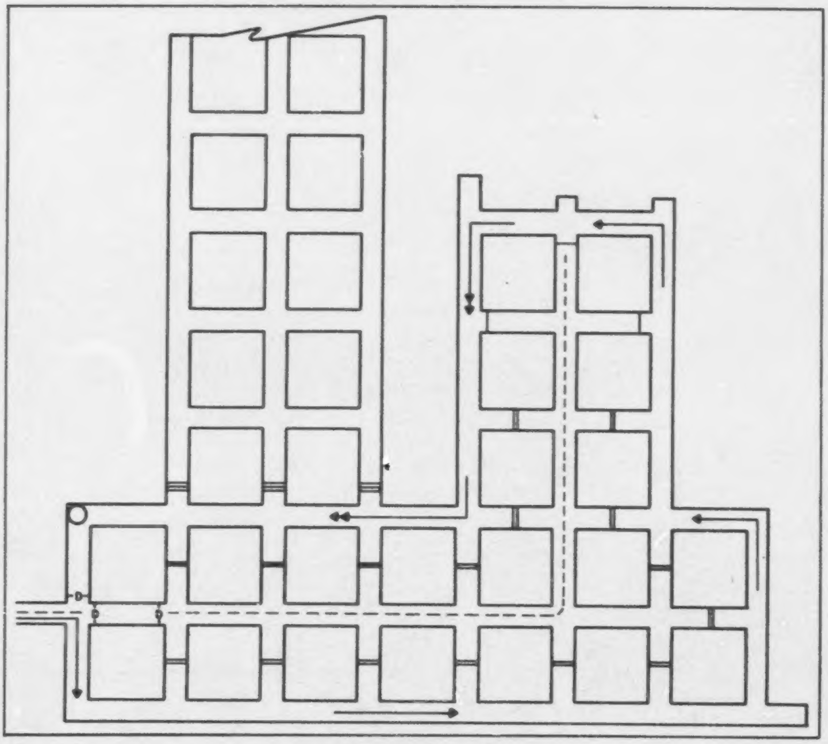
2. Together, cumulative federal and state regulatory requirements substantially affect development of study sites and development activities involving surface mining, the siting of synthetic fuels facilities, powerplants, transportation and utility corridors, port facilities, and marine transportation systems.
3. Proper utilization of integration provisions contained in Council on Environmental Quality environmental review with planning and decision-making regulations implementing the National Environmental Policy Act (NEPA) and with simultaneous utilization of existing interagency and intergovernmental mechanisms, provide a significant opportunity to expedite federal and state regulatory requirements for coal mining, synfuels facility, and transportation systems.
4. Active participation by affected federal, state, local, native and private entities in the development of District Coastal Zone Management Programs (in concert with NEPA EIS requirements) to ensure adequate consideration of the siting of "use of State concern" and "national interest" in coal development is needed to preserve acceptable sites in study areas for future development and expedite federal and state regulatory requirements.

RECOMMENDATION

The State of Alaska (in concert with the Northwest Federal Regional Council) should conduct a joint study with the State of Alaska and affected units of local, native and federal government to (1) determine likely permit, license and approval scenarios, (2) identify institutional barriers to coal development at specific sites, and (3) prepare draft intergovernmental agreements and "memorandums of understanding" for expediting regulatory requirements.

WAINWRIGHT CENTRAL DISTRICT HEATING AND POWER GENERATION PROJECT

EXTENDED FEASIBILITY STUDY



VOLUME ONE
FEBRUARY 1982

arctic slope
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WAINWRIGHT CENTRAL DISTRICT HEATING AND POWER GENERATION PROJECT

Prepared for
NORTH SLOPE BOROUGH

VOLUME ONE

Prepared by
Arctic Slope Technical Services, Inc.
420 L Street, Suite 406
Anchorage, Alaska 99501

February 1982

arctic slope
technical services
incorporated
420 L STREET • ANCHORAGE, ALASKA 99501 • TELEPHONE (907) 276-0517

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15 February 1982

North Slope Borough
P. O. Box 69
Barrow, Alaska 99723

ATTENTION: Irving Igtanloc
Director of Public Works

SUBJECT: Final Report on Extended Feasibility Study of Wainwright Central District Heating and Power Generation Project

Gentlemen:

Arctic Slope Technical Services takes pleasure in submitting herewith the subject final report.

In preparing the final report, the consultants have taken account of comments received in the course of the NSB review of the draft report.

When the draft report was submitted, the calculation of capital costs had not been completed. This has now been done, and when doing so, building costs have been estimated on the basis of approximate unit costs per square foot being currently experienced on the North Slope.

The revised unit costs now indicate:

- That it would not be economical to develop a mine for the purpose - whether interim or long term - providing coal solely for individual direct space heating by coal furnaces.
- That coal-fired central district heating by a fairly small margin - \$2,390 per annum versus \$2,700 per annum for continued use of fuel oil for heating a 960 sq. ft. house - is the perferred alternative.

In view of this narrow margin it may be advisable to take another hard look at the economics of the preferred alternative. In particular the following factors should be examined more carefully:

- Whether the funding as set out by the Borough at the outset of this study is still applicable.

- Detailed costs for the proposed buildings and the distribution system.
- Whether the cost of a covered coal stockpile is unavoidable.
- Whether other economics could be made in the building areas.
- Whether labor costs used for the calculation are likely to attract villagers.

It should be noted, that the cost of coal is quite high in the revised calculation.

- $140 per ton at a production of 4,000 tons per annum for the preferred alternative.

If coal were produced for export, for example to Point Lay and Point Hope and the quantity thereby were f. ex. 10,000 tons per annum, the cost would be only $93.60 per ton.

Finally, if low cost natural gas for Barrow is likely to be a thing of the past five years hence, the production of coal at Wainwright for coal-fired generation of electricity for Wainwright and for transmission by the proposed intertie to Atqasook and Barrow may be worthy of investigation.

We do feel that the project final report is comprehensive and adequate, but if you have any questions or need any further details, please do not hesitate to call us. We will only be happy to clarify any doubt there might be.

Very truly yours,

ARCTIC SLOPE TECHNICAL SERVICES, INC.

S/Leland A. Johnson, P.E.
President

LAJ: mm

Enclosure

1.0 GENERAL BACKGROUND

1.01 This feasibility study is an extension to an initial feasibility study entitled "Feasibility Study on District Heating System for Wainwright", which was produced by this consultant and submitted to the North Slope Borough under cover of a letter dated July 31, 1980.

The subject extension study is authorized by purchase order No. 14035, dated November 25, 1980, adjusted September 16, 1981 and in accordance with N.S.B. Standard Service Agreement date 19th November 1980.

1.02 The object of this extension study is to narrow down the choice between several alternatives for power generation and space heating, which in the initial study were recommended for further study.

A further object is to enable a choice to be made as to mine location and mining method. Also to enable the NSB to decide, whether power generation and heating fluid reheating should take place at the mine-mouth or at the village.

Finally, two associated technologies were investigated for possible inclusion in a final recommendation, namely:

- Organic Rankine Cycle power generation, and
- Dual-fuel stoves or furnaces for interim use of coal for space heating of individual homes.

During negotiations with the NSB about the work program for the subject extension study, mention was made of the need to study the influence of possible retrofit energy conservation measures on the future space heating energy demands. The NSB felt at the time, that this should be tackled on another occasion. This subject will be taken up under our recommendations for further work to be done.

1.03 During the work performed under the subject extension study and in formulating the recommendations we have been conscious of the need to provide speedy interim relief to villagers in the form of coal supplies for direct heating of the individual homes pending the implementation of a Central District Heating System, if the indications are, that the latter requires a fairly long time-span for implementation.

2.0 EXECUTIVE SUMMARY

2.01 Outline of Work Program

The work program for the subject study was divided into the following main tasks:

Task 1: Designing of exploratory drilling program.
Permit acquisition for exploratory drilling program.
Permit and licensing analysis for construction and operation.

Task 2: Contracting for field drilling.

Task 3: Implementation of exploratory drilling program.
Production of geological data.

Task 4: Geologic data evaluation and preliminary mine design.

Task 5: Selection of alternatives, evaluation of alternatives.
Investigation of Organic Rankine Cycle generation.

Task 6: Investigating interim house installations.

Task 7: Ascertaining the views of the Wainwright village people.

Task 8: Production of final report including scope of further work required for implementation.

2.02 Essence of Recommendations

Our recommendations can be briefly summarized as follows:

2.02.1 Mine location: Location A-B, about 1/2 mile northeast of Wainwright's outskirts, is recommended as the most suitable mine location, as shown in plan 12.1 following page 12-1.

2.02.2 Mining method: It is recommended that a 6 ft. coal seam about 120 ft. under the surface be mined underground using a "dintheader" excavator and shuttletrucks. Mining will take place in short periods, which will be scheduled to avoid the summer period and all important hunting and fishing seasons.

2.02.3 Central District Heating

During the course of our work under the subject extension study we have concluded that we should recommend that the long term development should be based on alternative A-II (coal-fired low pressure heaters providing central district heating, the existing diesel generating plant producing electricity). Alternatives A-1 (counterpressure steam co-generation) and A-2 (condensation steam generation coupled with space heating by electricity) are no longer regarded as methods to be recommended for reasons given in Section 11.0.

It is recommended that implementation takes place in the undermentioned phases:

Phase 1:

- Development of preferred mine site, storage facilities and means of transportation to enable mining to take place under limited permit (20 tons per annum per household) for individual home heating and capable of being expanded into phase 2.

- Installation of coal-burning stoves or furnaces for interim use and later back-up in individual homes, if village people show sufficient interest in such interim usage.

- Implementation of retrofit energy conservation measures.

Phase 2:

- Central District Heating based on coal-fired low pressure heaters.

- Phase 2 could be subphased to coincide with requirements of the NSB as regards funding and new housing developments.

Phase 3:

- Introduction of ORC-generation to supplant diesel-generation, as and when warranted by prevailing conditions and needs also by emerging experience with commercially available ORC-plant.

- It is noted that the Alaska Power Authority are proposing to fund a pilot ORC-generation plant in a Northwest Alaskan village based on the firing of a solid fuel. Consideration should be given to seeking to have this pilot operation sited in Wainwright.

2.02.4 Timing of Development

Subject to obstacles to development described in Section 18 being resolved, and subject to village confirmation of this view, it is recommended, that the primary aim be to pursue development of the Central District Heating concurrently with the mine development reference Section 13.0, Volume 1.

2.02.5 Further Work Prior to Final Design

It is recommended that further work be undertaken in preparation for final design of facilities as set out in Section 20.0.

3.0 EXPLORATORY DRILLING PROGRAM

The report on the exploratory drilling program called for in the work plan for the present study is for convenience of reading being presented as a separate volume, Volume 2. This covers tasks 1,2, and 3 of the work plan.

4.0 GEOLOGIC DATA EVALUATION AND PRELIMINARY MINE DESIGN

The report on geologic data evaluation and preliminary mine design is likewise being presented as a separate volume, Volume 3. This cover Task 4 of the work plan.

5.0 PERMIT AND LICENSING ANALYSIS FOR PROJECT CONSTRUCTION AND OPERATION

5.1 Introduction: Scope and Purpose

This section discusses those federal and state environmental permits, licenses, and other authorizations that will and will not be required for the construction and operation phases of the project. In the course of this discussion, applicable laws, regulations, agency concerns, and permit application requirements, fees, and processing time frames are identified. Two critical path diagrams summarizing the necessary environmental authorizations and associated processing time frames are found at the end of this chapter.

The above information is intended to provide the North Slope Borough with a useful framework for determining when and how to apply for each environmental permit or license, as well as a better understanding of any particular environmental concerns that an agency may have. We are aware that various additional authorizations may be required (e.g., a Water Rights Permit from the Alaska Department of Natural Resources, a Public Utilities Certificate from the Alaska Public Utilities Commission, and various State building approvals and requirements); however, the discussion of such authorizations is beyond the scope of this report in that they are not expressly environmental in nature. Nevertheless, of all the authorizations required, it is those discussed in this section that will demand the bulk of the Borough's time and energies to obtain.

This analysis is complicated by the fact that all the proposed project sites are situated within the National Petroleum Reserve in Alaska (NPR-A) and on village native corporation (Olgoonik Corporation) lands. Hence, subsurface rights to minerals are owned and controlled by the federal government, while surface rights are owned and controlled by the Olgoonik Corporation. As will be discussed later, this rather unusual situation has led to jurisdictional uncertainties with respect to the Bureau of Land Management and the Office of Surface Mining.

5.2 Basic Assumptions

Since final project design is not yet known and final site selection has not been completed, certain assumptions were made concerning the mining operation and electrical generating facilities. These assumptions are stated below.

5.2.1 Project Options

The following two project options--each with its own set ofbasic assumptions--are discussed throughout this section.

5.2.1.1 Full Scale Coal Mining, Processing, and Power Generation

This preferred option (herinafter referred to as the "Full Scale Development Option") would involve the excavation and operation of a mine occupying an area of up to two acres per year (total area of 60 acres or less) over a 20- to 30-year lifespan, with up to 10,000 tons per year of coal mined, the construction and operation of power generation facilities either at the mouth of the mine (most likely) or in Wainwright, and the construction of related facilities such as storage piles and roads. Any liquid mine wastes generated through subsurface mining would be used in the formation of ice backfill to be placed in the mined-out rooms.

Power generation facilities most likely would consist either of new low pressure coal-fired water heaters or new coal-fired boilers connected with steam turbines that, in turn, are coupled to electrical generators. Design of these facilities would be the same as that of one of two recommended alternatives referenced in the July 1980 initial feasibility study report entitled Wainwright Central District Heating System: Alternative A-1 (coal-fired steam turbines), with a rating of approximately 31 million Btu/hour; or Alternative A-II (low pressure coal-fired water heaters), with a rating of approximately 21 million Btu/hour.

5.2.1.2 Small Scale Coal Mining

This option (hereinafter referred to as the "Interim Option") would involve only the excavation of coal to be used expressly for domestic heating purposes, with a maximum of 20 tons of coal mined per family per year (i.e., a total of approximately 2,400 tons per year) for burning in the home. This option would not involve processsing, power generation, water use or wastewater generation, or the construction of any facilities related thereto, and would be temporary in nature. It would also involve the construction of related facilities such as storage piles and roads.

Either option could entail surface or subsurface mining, although the latter is the most economically feasible and, hence, the preferred option. Neither option would require the construction of a basecOmp; current residents of the town of Wainwright would "commute" to the mine from home during all phases of the project. Neither option would involve any activity affecting the Kuk River (e.g., inwater work, above-ice travel, bank distubances, water withdrawals, and discharges of wastewater, mine tailings, or other materials into the River). Neither option would require any coal preparation/ cleaning plant with thermal driers or pneumatic cleaners; only crushers and screeners might possibly be needed in the preparation of the coal.

5.2.2 Site Options

As noted elsewhere in this report, of the three potential project areas that have been considered (Areas A-B, C, and D), Area A-B is the preferred project area. The project will be sited to avoid any individual native allotments.

5.3 Approach to Information Gathering

First, the State of Alaska's "Directory of Permits" was screened for all possibly relevant federal and state environ- mental requirements. Next, applicable laws, regulations, and other appropriate materials were researched and analyzed. Finally, representatives of federal and state environmental agencies were contacted in order to obtain their views as to the manner in which such laws and regulations will be interpreted.

5.4 Results

The results of the regulatory analysis that follows are organized by individual agency, grouped in terms of federal and state agencies.

5.4.1 Federal Agencies

5.4.1.1 Bureau of Land Management (BLM)

A. Coal Lease and License to Mine

1. Jurisdictional Authority

Title 43, Group 3400, of the Code of Federal Regulations (CFR), entitled "Coal Management", describes the BLM's authority and responsibilities for managing coal on "Federal lands" pursuant to various federal laws, including the Mineral Leasing Act of 1920, as amended (30 U.S.C. 181 *et seq.*), the Mineral Leasing Act for Acquired lands of 1947, as amended (30 U.S.C. 351-359 *et seq.*), and the Federal Land Policy and Management Act of 1976 (43 U.S.C. 1701 *et seq.*). "Federal lands" are defined as lands owned by the United States, without reference to how the lands were acquired or what federal agency administers the lands, including mineral estates or coal estates underlying private surface, but excluding land held by the United States in trust for Indians, Aleuts or Eskimos (43 CFR 3400.0-5(t)).

As noted above, the project areas would be situated within NPR-A lands, the subsurface estate of which is owned by the federal government and the surface estate of which is owned by a private corporation (the Olgoonik Corporation). The project would not involve any lands held by the United States in trust for the Eskimos. Hence, the project would be conducted on "Federal lands" subject to BLM management.

The BLM's responsibilities for managing coal on Federal lands includes the authority to issue Coal Leases and Licenses to Mine.

a. Coal Lease

The Full Scale Development Option cannot be implemented without a BLM Coal Lease (Gal, 1981, Clithero, 1981), the specific regulations for which are contained in 43 CFR 3420 and 43 CFR 3422. However, under present law and regulations, the BLM is not authorized to issue Coal Leases within the NPR-A (National Petroleum Reserve Production Act of 1976 (P.L. 944-258); 43 CFR 3400.2(a)(7)). Were an application for the Full Scale Development Option submitted today, the BLM would have no alternative but to deny a Coal Lease for that proposal (Gal 1981). Hence, the Full Scale Development Option is not a viable option at present.

Nevertheless, a movement is currently afoot to open the NPR-A to coal leasing. In the latter part of 1980 -- through a stipulation in P.L. 96-514, the U.S. Department of the Interior's 1981 appropriations bill -- the NPR-A was opened to petroleum leasing (Gal 1981). In July, 1981, U.S. Senator Frank Murkowski wrote then-North Slope Borough Mayor Jacob Adams that he was investigating the possibility of introducing legislation allowing the Borough to mine coal within the NPR-A (Murkowski 1981). The BLM Fairbanks Office has also informally requested BLM headquarters in Washington, D.C. to investigate the prospect of similar legislative initiatives allowing the BLM to lease coal within the NPR-A (Gal 1981).

While, as of this writing, the NPR-A is still closed to coal leasing, the possibility of a reversal of this policy in the offing is sufficient to further consider the Full Scale Development Option throughout the remainder of the report.

b. License to Mine

The Interim Option was conceived as an interim means of partially meeting Wainwright's domestic heating needs until such time as the NPR-A can be opened to coal leasing for a full scale coal development project. Section 8 of the Mineral Leasing Act of 1920 and 43 CFR 3449 authorize the BLM to issue a License to Mine, within the NPR-A as elsewhere on federal lands, to a municipality for a period of four years (subject to renewal), provided the mining is for nonprofit, household uses only and that no more than twenty tons of coal per family per year is mined (Clithero 1981, Gal 1981). The Interim Option, as presently contemplated, would meet the above criteria and would, therefore, qualify for a License to Mine.

2. Application Requirements, Processing, and Fees

a. Coal Lease

If the NPR-A is opened to coal leasing, and coal land or deposits contained therein become available, they will be divided into suitable leasing tracts by the BLM and leased competitively. Prior to a lease sale, the BLM will publish a notice of the sale in the Federal Register and in a newspaper of general circulation in the area affected by the sale. The notice will show the time and place of the sale, whether it will be by public auction or sealed bids, the description of the land, and where a detailed statement of the terms and conditions of the lease offer may be obtained. The successful bidder must reimburse the Government for the cost of publishing that notice, as specified in the detailed statement.

The applicant must provide with his bid a statement of citizenship, a complete and accurate description of the land, and a description of the coal deposit located therein. Total holdings in licenses and leases for coal may not exceed 46,080 acres.

On the day of the sale, each bidder must submit one-fifth the amount of his cash bonus bid. Bids are received only until the hour on the date specified in the notice of competitive leasing. All sealed bids are read. If the procedure calls for sealed bids followed by oral bids, the oral bidding will begin at the level of the highest sealed bid received. After the oral bidding has ceased, the highest bidder will be announced. No decision to accept or reject a bid is made at this time. The successful bidder is notified in writing after the sale and the deposits on all rejected bids are returned.

Four copies of the lease are sent to the highest bidder who must execute them within 30 days after his receipt thereof, pay the first year's rental, and file any bond required. The balance of the cash bonus is to be paid in four equal installments, payable on the first four anniversary dates of the lease.

It generally takes approximately 90 days for the BLM to issue a Coal Lease from the date it receives a complete application, provided an Environmental Impact Statement (EIS) is not required (see further discussion of Environmental Assessments (EAs) and EISs under Section 5.4.1.1(A)(2)(c) below) (Clithero 1981). Coal leases will be issued for twenty years and extended for as long thereafter as coal is produced in commercial quantities. The lessee must pay an annual royalty of 12-1/2 percent of the value of the coal from a surface mine, or eight percent of the value of the coal from an underground mine.

b. License to Mine

Four copies of the official BLM application for a "license to mine coal for domestic needs" must be filed with the BLM State Office having jurisdiction over the project areas (43 CFR 3440.1-1(a)). A non-refundable fee of $10.00 must accompany each such application or renewal application (43 CFR 3473.2-1(a)(2)). Provided application is made during the summer, it ordinarily takes approximately 30 days for the BLM to issue a License to Mine from the date it receives a complete application, including time allocated for EA preparation (Gal 1981) (see further discussion).

c. National Environmental Policy Act of 1969 (NEPA) EA/EIS Requirements

For the purposes of NEPA, the BLM would most likely be the lead agency where a Coal Lease or License to Mine application is involved. An EA, not an EIS, would most likely be prepared before either of these two BLM authorizations are granted (Gal 1981, Clithero 1981, Reynolds 1981). Although the time frame for preparation of an EA could be variable, it would be particularly brief for a License to Mine application, since such application generally takes a total of only 30 days to process (Clithero 1981). The applicant can expedite the process by helping to provide the needed environmental data (Reynolds 1981).

For both Coal Lease and License to Mine applications, EA preparation would entail a routine assessment of possible archeological resources, endangered species, and individual native allotments at the selected projects area. The latter two factors are expected to be non-existent at all potential project areas; however, if archeological resources are discovered (also an unikely possibility), a Federal Antiquities Permit (43 CFR 3) might be required if the applicant is unable to avoid such resources. If such resources cannot be avoided, and if the BLM, after consultation with the State Historic Preservation Office (Anchorage), determines that such resources need to be excavated for preservation purposes, then the BLM must apply to the National Park Service for an Antiquities Permit. Issuance of such a permit takes 30-60 days from the time application is made, thereby slowing the BLM's licensing/leasing process by a corresponding amount of time (Clithero 1981).

Before finalization, the BLM's EA is first sent to the Alaska Department of Fish and Game, Department of Environmental Conservation, and other State agencies for review and comment (Reynolds 1981).

B. Other BLM Environmental Authorizations

1. Free Use Permit for Disposal of Mineral Materials

a. Jurisdictional Authority

43 CFR 3620 authorizes the BLM to issue a Free Use Permit to municipalities and other government units wishing to use, free of charge, mineral materials (including gravel) situated on Federal lands. Since the North Slope Borough would need to excavate gravel for both project options in the construction of associated storage piles, access roads, and other facilities, the Borough would first have to obtain a Free Use Permit if it intended to extract such mineral materials from Federal lands.

b. Application Requirements and Review Process

Applicants for a Free Use Permit should submit to the BLM a completed Form 5510-1 entitled "Free Use Application and Permit." Where a License to Mine is also required, applications for both authorizations may be submitted simultaneously (Gal 1981). The BLM would, in this case, prepare an EA covering both applications. Since a village native corporation controls the surface estate of the project areas, that corporation's concurrence with the proposed project would be required before a Free Use Permit could be issued. As with the License to Mine, it ordinarily takes the BLM approximately 30 days to issue a Free Use Permit from the date it receives a complete application, assuming application is made during the summer. The Free Use Permit is usually issued for a total of two years (one year initially plus one year extension), although it may be issued for a maximum of ten years for such governmental units as the BorouhF(Clithero 1981, 43 CFR 3621.1(b)).

2. Right-of-Way

Right-of-Way easements, licenses, or permits from the BLM, pursuant to 43 CFR 2800, are not required for any of the project areas or options because the entire affected surface estate is owned by a village native corporation, not by the Federal Government.

5.4.1.2 Office of Surface Mining (OSM)

A. Jurisdictional Authority

The Surface Mining Control and Reclamation Act of 1977 (SMCRA)(30 USC 1201) established the OSM with the view of regulating all surface coal mining operations, including, by definition, the surface effects of underground mining. Section 506 of SMCRA and 30 CFR 700 through 899--the OSM's final regulations implementing SMCRA--require all persons seeking to engage in surface coal mining and reclamation operations to obtain a permit either from the OSM or from a State with a federally-approved program, as appropriate. Although Alaska is not yet a transfer State for the SMCRA permitting program, it is currently in the process of submitting a State plan for primacy under SMCRA. Where State plans have been approved, this transfer process has generally taken from six to eight months (M. Smith 1981).

It is uncertain at present whether SMCRA regulations apply, and, therefore, whether a permit from the OSM would be required within the NPR-A for the two options contemplated. Interviews with various government officials revealed that no consensus of opinion exists on this subject. Former North Slope Borough Attorney Conrad Bagne takes the position that SMCRA regulations do not apply within the NPR-A (Bagne 1981). Since SMCRA regulations apply only to surface mining on Federal lands, and the surface portions of the project sites are all situated on private (Olgoonik Corporation) lands, it might be argued that these sites are, therefore, all located outside the jurisdiction of the OSM and its SMCRA regulations. Bob Gal, former BLM Acting Project Manager for the NPR-A (Fairbanks); Bill Clithero, BLM Realty Specialist (Anchorage); Murray Smith, OSM Chief of State and Federal Programs (Denver); and Mary Josie Smith, member of an OSM team that is presently rewriting the SMCRA regulations (Washington, D.C.) are all uncertain as to whether SMCRA regulations apply within the NPR-A (Gal 1981, Clithero 1981, M. Smith 1981, M.J. Smith 1981). Carl Close, OSM Assistant Director for State and Federal Programs (Washington, D.C.), is fairly certain that present SMCRA regulations and OSM permitting requirements *do* apply within the NPR-A and directly to the Wainwright project (Close 1981). To complicate matters, the OSM is, as of this writing, revising its SMCRA regulations, with publication of these revised regulations expected in the Federal Register by mid-1982 (M.J. Smith 1982).

Despite the present uncertainty as to whether the Wainwright project options will need an OSM permit, the following discussion assumes that both will.

B. Application Requirements

The following information on SMCRA application requirements is derived from Joyce (1980).

Extensive information is required in OSM permit applications. Data required can be classified into three basic categories: (a) legal, financial, compliance and related information; (b) environmental resource information; and (c) reclamation and operation plans.

Differences exist between data required for the mine plan area and for the permit area. For example, information on hy- drology must cover the entire mine plan aréa, while soil resource data need describe only the permit area. OSM defines mine plan area as "the area of land and water within the boundaries of all permit areas during the entire life of the surface coal mining and reclamation operations. At a minimum, it includes all areas that are or will be affected during the entire life of those operations." Permit area means "the area of land and water within the boundaries of the permit which are designated on the permit application maps." The permit area may be smaller than or equal to the mine plan area.

1. Minimum Legal, Financial and Related Information

An application must include names and addresses of the applicant, operator, property leaseholder, principal shareholders, and company officers. Previous permits held since 1970 by these persons must be noted, as well as whether any permits were revoked or suspended in the previous five years. A history of any bond forfeiture must be included as well as a list of previous violations of state or federal surface mining-related law. Other types of permits needed to mine coal, such as those under state law or for the U.S. Environmental Protection Agency, must be listed, as well as information on any area that eventually may be unsuitable for mining under the regulations' unsuitability criteria.

2. Minimum Information on Environmental Resources

Most of the permit preparation work will be dedicated to acquiring information on the environmental resources of the permit and adjacent areas. The data requirements are as follows:

a. Geology Description

Test borings and core samples down to and including the stratum immediately below the lowest coal seam to be mined are required. Also to be included are the physical characteristics of each stratum, analysis of the coal seam, and location of subsurface water. Waivers from these requirements can be obtained. Preliminary exploratory core drilling that ASTS completed in July, 1981 may be insufficient to meet the permit requirements. Coal quality analysis should be sufficient to meet these requirements.

b. Ground and Surface Water

A description of ground water for the mine plan and adjacent area must be supplied. Streams, lakes, ponds, and springs in the mine plan and nearby areas must be identified. Extensive information describing surface water is required. If mining could adversely affect the water users in the area, the permittee must identify alternative sources of water.

c. Climatological Information

The regulatory authority may request precipitation, wind and temperature data. Such a request will likely be made if climatic conditions -- winds, temperatures, rainfall -- have led to past problems with revegetation or air pollution. Air quality monitoring may be requested as part of OSM's air quality rules.

d. Vegetation Information

The regulatory authority may also request a map and description of vegetation in the proposed permit area. If adjacent areas happen to be important habitats for the area's fish and wildlife, they must be described. A map and description of "reference area" vegetation (used as a basis for measuring revegetation success) may also be required.

e. Fish and Wildlife Information

An operator must include a fish and wildlife study for the mine plan area if mining is expected to affect those resources. The regulatory authority, after consultation with federal and state fish and wildlife experts, will set the level of detail for required information. As with other permit application data, existing data may suffice if available; otherwise, the applicant must generate the information.

f. Soil Resources

All applicants must provide a map and description of soils in the proposed permit area. Each soil category must be described, as well as information on present and potential productivity. If overburden is to be used as a topsoil substitute, the results of chemical analyses and field site trials or greenhouse tests must be included.

g. Land Use

An application must include a description of land capability and productivity, such as average yield of food, fiber, forage or wood products before mining, for the permit area. Also to be listed are land uses and classifications under local law for the mine plan and adjacent area. Available data will suffice for this requirement. Details of any previous mining activity must be outlined.

h. Maps

An operator must draft maps that depict different geographical or legal (ownership) characteristics. Eleven geological characteristics must also be mapped, including location of ground and surface water and elevations and locations of test borings or core samplings.

3. Minimum Information on Reclamation and Operation Plan

The third major part of a permit application must describe how the operator plans to comply with the rules during mining and reclamation. Most plans are to be prepared for the permit area, but others, particularly those for protecting hydrologic balance, must apply to the mine plan area.

a. Operation Plan

Methods and the amount of coal to be mined must be described, as well as how the operator will use and then remove struc- tures necessary for mining. A description of existing struc- tures and proof that they meet the performance (but not design) standards of the rules must also be prepared. By performance standards, OSM means desired results such as effluent levels, safety factors, revegetation levels, etc. Design standards are engineering specifications that set down how a structure must be built, such as those that apply to embankments and ponds.

b. Blasting Plan (Surface Mines Only)

Blasting plans must be detailed, showing proposed drilling patterns and charges, packing of holes, types of fuses and detonation controls, and sequence of firing. Methods for monitoring and for warnings must be described, as well as procedures for site access.

c. Maps and Plans

More mapping beyond that needed for environmental resources reporting is required. Besides showing the areas to be affected by mining and reclamation, maps must show buildings, coal and spoil storage areas, water treatment and control stuctures, air pollution control facilities, waste sources and disposal sites, ponds, explosive storage sites, and wildlife control facilities. Maps for coal storage, topsoil and spoil storage, explosives storage and ponds and impoundments must be prepared under the supervision of a registered professional engineer or professional geologist.

d. Air Pollution Control

All surface mines must outline plans for fugitive dust control methods.

e. Fish and Wildlife Plan

The operator must describe how effects on wildlife will be minimized, and how the operation will "achieve a condition which clearly shows a trend toward enhancement" when revegetation is complete. If a "trend toward enhancement" cannot be shown, reasons must be given. The operator must describe measures he will take to protect threatened or endangered species and other species protected by state or federal law, as well as their habitats, if they will be affected by mining. These habitats include wetlands, riparian areas, and areas offering special shelter or protection to these classes of wildlife.

f. Reclamation Plan

The reclamation plan must show methods of backfilling, soil handling and stabilization, grading, revegetation and other reclamation methods, and a schedule for their completion. Methods to protect water quality and quantity, ownership of water rights, and procedures that will be followed to restore recharge capacity and water quality must be explained. A description of probable hydrologic consequences of mining for both the permit and adjacent area is also necessary, as well as proposed spoil disposal methods.

g. Post-Mining Land Use

Applications must describe proposed post-mining land uses, along with comments on such uses from the surface landowner and state agencies.

h. Water Control Plan

Applications must include a general plan for each proposed sedimentation pond, water impoundment, and coal processing waste bank, dam or embankment, and explain how they will meet performance rules. A geotechnical investigation must be made of proposed waste dams and embankments. Operators must also describe proposed stream diversions.

i. Effect on Roads

Each application must describe in detail proposed haul roads, conveyors or rail systems to be used, and how they will be built. Effects on public roads must be outlined if mining is proposed within 100 feet of the right-of-way line or if a public road is to be relocated. The outline must include a description of how public and private landowner interests will be protected.

j. Protection of Public Parks and Historic Places

If mining is expected to adversely affect public parks or historic places, applications must describe what measures will be taken to mitigate these effects.

k. Disposal of Excess Spoil

Applications must describe, using maps and cross-section drawings, how and where spoil will be disposed. A geotechnical investigation of the proposed site is necessary.

l. Transportation Facilities

Applications must describe each road, conveyor or rail system to be built or used within the permit area. The description must include a map, cross-sections, and specifications for road width, gradient, surface and cut, fill embankment, culvert, bridge, drainage ditch and drainage structure.

C. Review Process (Joyce 1980)

1. SMCRA allows citizens and public and private agencies to participate in the permit review process. Besides publishing a notice of application for a permit in a local newspaper, an operator must allow the public to examine his complete application. Citizens can challenge applications or revisions and call for an informal conference with the regulatory authority. Citizens can have access to the mine area to gather information for such a conference. Some information contained in the application is confidential, however, including the operator's analysis of the chemical and physical properties of the coal to be mined. Data on potentially toxic mineral or elemental contents of coal to be mined is not confidential.

2. It ordinarily takes the OSM one year to issue a permit from the date on which a complete application is received (M. Smith 1981).

3. A citizen may challenge an approval or denial of an application within 30 days of its issuance. A hearing must be held within 30 days of the challenge, and the hearing authority then has 30 days to rule. A decision may be appealed by the citizen to a local court.

4. Approval Criteria

To obtain a permit, an applicant must prove to the regulatory authority that mining and reclamation under the performance standards is feasible, and that land to be affected is not located on areas designated (or under consideration for designation) as unsuitable for mining. He must show proof that his reclamation fees on existing operations have been paid, and must submit his performance bond before receiving the permit.

5. No application will be approved unless the applicant can prove that existing structures on the site will meet performance standards. If an existing structure cannot be rebuilt to meet those standards without harming the environment, it must be abandoned.

6. If an operator who is currently mining applies for another permit, he must show that he is either not currently violating any state law or regulation related to air, water or soil protection, or show that his violation is being remedied or is under formal appeal. The regulatory authority will pay special attention to an applicant's record of compliance with SMCRA.

7. Once a state program is approved, an operator has eight months to obtain a permit. Also, if an informal conference on the application is held after a citizen request, a permit application must be processed and acted upon within 60 days after the close of the conference.

D. Permitting Process (Joyce 1980)

Figure 5.1, below, summarizes the OSM's permitting process.

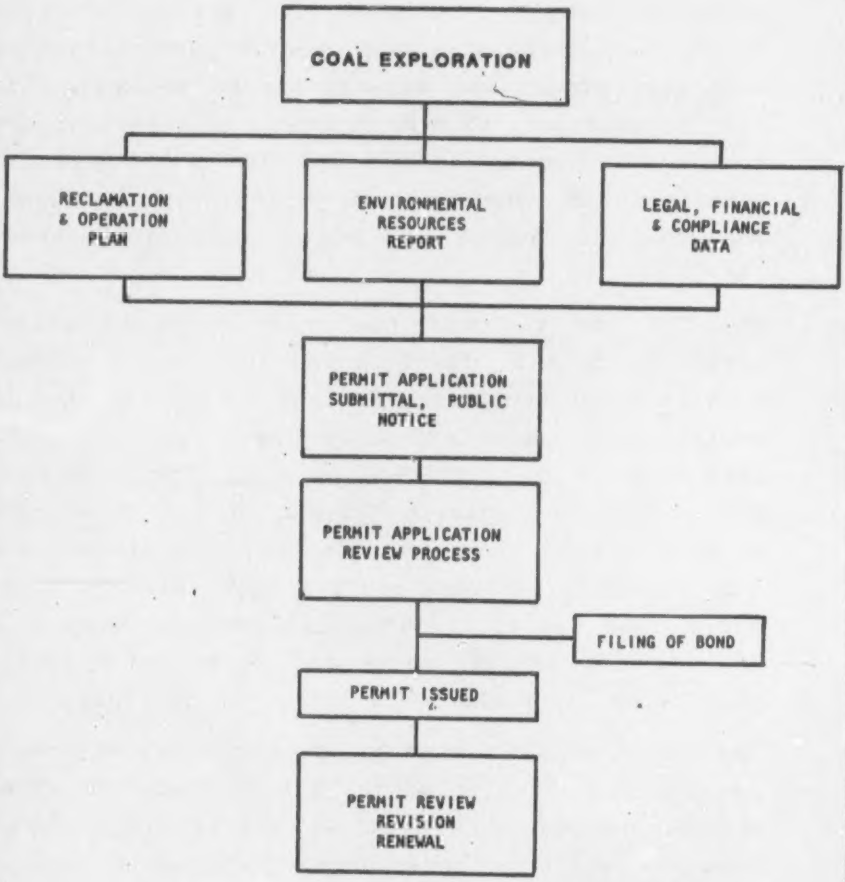
5.4.1.3 U.S. Bureau of Indian Affairs (BIA)

The project will be sited to avoid any individual native allotments, and none of the project areas constitute "Indian lands" as defined in 25 CFR 177.101. Hence, the BIA's regulatory authority over surface exploration, mining, and reclamation of Indian lands pursuant to 25 CFR 177 does not apply. Nor are BIA Rights-of-Way or Land Lease Authorizations for Indian lands required pursuant to 25 CFR 161 and 25 CFR 131, respectively (Cronister 1981, Clithero 1981).

5.4.1.4 U.S. Army Corps of Engineers (COE)

A. Jurisdictional Authority

The COE'S permit program is authorized under Section 404 of the Clean Water Act of 1977 (33 U.S.C. 1344) and Section 10 of the River and Harbor Act of 1899 (33 U.S.C. 403). These laws require permits (collectively referred to as Section 10/404 permits) for the discharge of dredged or fill material into "waters of the United States" (including adjacent wetlands) and for structures and work in or affecting "navigable waters of the United States" (a subset of "waters of the United States").


COAL EXPLORATION
RECLAMATION & OPERATION PLAN
ENVIRONMENTAL RESOURCES REPORT
LEGAL, FINANCIAL & COMPLIANCE DATA
PERMIT APPLICATION SUBMITTAL, PUBLIC NOTICE
PERMIT APPLICATION REVIEW PROCESS
FILING OF BOND
PERMIT ISSUED
PERMIT REVIEW REVISION RENEWAL

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 5-1: Summary of OSM Permit Process(After US Dept. of Interior)

The North Slope of Alaska contains vast areas of moist tundra and wet tundra, much of which the COE's Alaska District has been classifying as "adjacent wetlands" subject to its Section 404 jurisdiction. While the District is presently undertaking an extensive program to map all Alaska wetlands under its jurisdiction, this program will not be completed for years. Hence, in the interim, the District is continuing to make wetlands jurisdictional determinations on a case-by-case basis (Wolfe 1981, Reeder 1981).

The COE has reviewed the three proposed project areas, and has found each to contain tundra constituting "adjacent wetlands" subject to its Section 404 jurisdiction (Rockwell 1981). A COE permit would be required for both the Full Scale Development and Interim Options at all three areas because both options would entail the discharge of fill material (gravel, crushed rock, mine tailings, etc.) into "adjacent wetlands" for the purpose of constructing storage piles and roads and disposing of mine tailings (Rockwell 1981, Caruth 1981).

The Kuk River, situated adjacent to Project Area C, constitutes a "water of the United States." Hence, any discharges of dredged materials into the Kuk River -- while not presently contemplated -- would also require COE authorization under Section 404 (Rockwell 1981).

B. Application Requirements

Applications for COE permits should be submitted on ENG Form 4345 and should include a detailed project description (including volume, type and configurations of fill materials and dimensions of structures) and a project plan, cross-section, and location map (33 CFR 325.1(b) and (c)). Since the project would occur within the coastal zone, the applicant must provide, along with ENG Form 4345, a certification that the project will comply with the Alaska Coastal Management Program.

C. Review Process

Shortly after receipt of all required information from the applicant, the COE issues a public notice describing the project proposal and stating the COE's preliminary determination of the need for and/or availability of an Environmental Impact Statement (EIS) (33 CFR 325.3). (This public notice is issued jointly with the Alaska Division of Policy Development and Planning's "Notice of Application for Certification of Consistency with the Alaska Coastal Management Program" and the Alaska Department of Environmental Conservation's "Notice of Application for State Water Quality Certification.") The COE has indicated that an EIS would probably not be required for either of the two project options and that, even if it were, the BLM, not the COE, would be the lead agency involved in its preparation (Wolfe 1981).

Copies of the public notice are sent to various federal, state, and local agencies, as well as to individuals and private organizations. These parties are, in turn, afforded a time period -- usually 30 days in duration, but in no case exceeding 75 days -- in which to forward to the COE comments on the public notice (33 CFR 325.2(d)(2)). The Alaska District generally receives the bulk of such comments from the following agencies (Wolfe 1981):

- U.S. Fish and Wildlife Service
- U.S. Environmental Protection Agency
- Alaska Department of Fish and Game
- Alaska Division of Policy Development and Planning
- Alaska Department of Environmental Conservation

In considering the comments of the above agencies, the COE fulfills, in part, Executive Order 11574's mandate that it consult with the U.S. Fish and Wildlife Service (US F&WS), the U.S. Environmental Protection Agency, and State fish and wildlife agencies throughout the Section 10/404 permit process. The Alaska Department of Fish and Game has indicated further that the COE generally concurs with its comments, usually incorporating in the COE permit any stipulations that it may request in order to protect fish habitats (Milke 1981).

Upon receipt of comments in response to the public notice, the COE forwards any adverse comments or objections to the applicant to afford him an opportunity to resolve or rebut them (33 CFR 325.2(a)(3)). The District Engineer has the discretionary authority to hold a public hearing on the permit application (and often does so for controversial and/or major projects) where it will assist him in making a decision (33 CFR 327.4).

In most situations where an EIS is not required the District Engineer is required either to deny a permit or to issue a draft permit for the applicant's acceptance within thirty days of one of the following, whichever is latest: Closing of the public notice comment period with no objections received; receipt of notice of withdrawal of objections; completion of coordination following receipt of applicant's rebuttal of objections; or closing of the record of a public hearing (33 CFR 325.2(d)(3)). The COE cannot issue a permit until Alaska's designated coastal zone agency, the Division of Policy Development and Planning, notifies the COE that it concurs with the applicant's Certification of Consistency with the Alaska Coastal Management Program (33 CFR 325.2 (b)(2)(ii)). This concurrence, in turn, is generally not reached until after the Alaska Department of Environmental Conservation issues a State Water Quality Certification (Wolf 1981) (see further discussion under Sections 5.4.2.1 and 5.4.2.2.A of this chapter).

It will take the COE approximately six months to issue (or deny) a permit for this project from the time it receives a completed application, assuming that the BLM requires no EIS (Wolfe 1981). The COE bases its decision whether to issue or deny a permit on a general balancing process, wherein the following factors, among others, are considered: conservation, economics, aesthetics, general environmental conerns, historic values, fish and wildlife values, flood damage prevention, land use, navigation, recreation, water supply, water quality, energy needs, safety, food production, and, in general, the needs and welfare of the people. No permit will be granted unless its issuance is found to be in the public interest (33 CFR 320.4(a)).

D. Fees

As an agency or instrumentality of local government, the applicant would be exempt from payment of any permit application fees (33 CFR 325.1(f)).

5.4.1.5 U.S. Environmental Protection Agency (EPA)

A. Prevention of Significant Deterioration (PSD) Permit--Air Quality

Neither project option would require a PSD Permit for the reasons discussed in detail below.

Sections 160 through 169 of the Clean Air Act, as amended in 1977, authorize the EPA to regulate, through a PSD permitting program, the construction or modification of certain designated sources of air emissions. The EPA has promulgated final regulations implementing this PSD program (40 CFR 52.21, dated August 7, 1980), the purpose of which is to prevent significant deterioration of air quality in areas of the nation that are cleaner than the National Ambient Air Quality Standards (40 CFR 50) require. The Wainwright project areas are all situated within an area of the nation that is cleaner that the National Ambient Air Quality Standards require. While the Clean Air Act provides for the transfer of the PSD program to the various states upon the EPA's approval of a State Implementation Plan (SIP), Alaska's SIP has not been approved to date (Hungarford 1981). Hence, all the Wainwright project areas potentially come under the EPA's PSD permitting jurisdiction. However, a PSD permit would only be required if the project entails the construction of a source of air emissions that meets certain criteria as designated in 40 CFR 52.2.1.

Sources of air emissions subject to PSD regulations under 40 CFR 52.21 consist of "major modifications" and "major sta- tionary sources." Since the project would involve a new source of air emissions, and "major modifications" pertains only to existing sources, this category of sources is inapplicable. The only types of "major stationary sources" that the project might potentially entail are:

- Fossil fuel-fired steam electric plants of more than 250 million Btu/hour heat input that emit, or have a potential to emit, 100 tons/year or more of any pollutant subject to regulation under the Clean Air Act (40 CFR 52.21 (b)(1)(i)(a)).

- Any stationary source (including fossil fuel-fired steam electric plants of less than 250 million Btu/hour heat input) that emits, or has a potential to emit, 250 tons/year or more of any pollutant subject to regulation under the Clean Air Act (40 CFR 52.21 (b)(1)(i)(b)).

As noted in Section 5.2.1.1 of this chapter, the Full Scale Development Option would entail the construction either of coal-fired steam electric turbines designed with a heat input of ± 21 million Btu/hour (Alternative A-1) or low pressure coal-fired water heaters designed with a heat input of±21 million Btu/hour (Alternative A-II). Hence, both alternatives of the Full Scale Development Option would consititute "major stationary sources" if, as "any stationary sources," they had the potential to collectively emit 250 tons/year or more of any pollutant regulated under the Clean Air Act. However, since preliminary samplings of coal at the project areas reveal very low ash and sulfur content, both Alternatives A-1 and A-II are expected to emit much less than 250 tons/year of each of such pollutants. As a consequence, a PSD Permit would not be required for the Full Scale Development Option (Nye 1981).

Since the only pollutant that the Interim Option would entail is fugitive dust (a non-point source), and non-point sources cannot trigger a PSD review, this option would also not require a PSD Permit (Nye 1981).

B. Compliance With New Source Performance Standards (NSPS)

NSPS are air emission limitations that apply to construction of any new stationary source of air pollution for which the EPA has issued performance standards. Pursuant to the Section 111 of the Clean Air Act, as amended in 1977, the EPA has issued and published performance standards in the Federal Register for certain stationary source categories. To date, no performance standards that apply directly to the atmospheric emissions from new source coal mines have been published. Nor are the EPA's new stationary source performance standards for electric utility steam generating units (40 CFR 60, dated June 11,1979) or for coal preparation plants (40 CFR 250) applicable to either project option (Nye 1981) for the following reasons:

- The standards for electric utility steam generating units apply only to such units with a heat input of 250 million Btu/hour or greater. Both Alternatives A-1 and A-II of the Full Scale Development Option have heat inputs of less then 250 million Btu/hour. The Interim Option would not include any electric utility steam generating unit.

- The standards for coal preparation plants apply to those capable of processing more than 181 metric tons (200 short tons) of coal/day, and entailing thermal dryers, pneumatic coal cleaning equipment, and/or coal handling and storage equipment. As was stated in the "Basic

Assumptions" above, neither project option would involve thermal driers or pneumatic cleaners. Furthermore, even if such a preparation plant were contemplated, neither project option would generate anywhere near 181 metric or 200 short tons of coal/day for preparation.

C. National Pollutant Discharge Elimination System (NPDES) Permit -- Water Quality

Section 402 of the Clean Water Act of 1977 (33 U.S.C. 1344) requires any owner or operator of a point source planning to discharge a pollutant into "waters of the United States" to obtain first an NPDES permit. The EPA regulations imple menting Section 402 of the Clean Water Act are contained in 40 CFR, Parts 121 through 125. NPDES permits are obtained either from the EPA or from the State, where the State program has been approved by the EPA pursuant to 40 CFR 123. Alaska does not yet have an approved State program; hence, applicants must still obtain NPDES permits from the EPA.

"Pollutant" is defined under 40 CFR 122.3, to mean "dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radio-active materials (except those regulated under the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.)), heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water." "Point source" is defined, under 40 CFR 122.3, to mean "any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel, or other floating craft, from which pollutants are or may be discharged."

As noted in the "Basic Assumptions" section of this chapter, the Interim Option would not involve the construction of a base camp or any water use or wastewater generation. Nor would it involve any other activities that could result in point sources of pollution subject to NPDES permit requirements. Hence, an NPDES permit would not be required for the Interim Option (Nasset 1981).

The "Basic Assumptions" also state that no base camp would be needed for the Full Scale Development Option; hence no associated gray water or sewage disposal facilities are anticipated. However, it remains uncertain whether this option would involve water use and wastewater discharges associated with mining operations and/or with steam turbines. Hence, technically speaking, the Full Scale Development Option could entail the point source discharge of pollutant(s) into "waters of the United States" and, if so, would require an NPDES permit. However, the EPA has informed us that, due to severe budget and staff cutbacks, it has been directed to require NPDES permits only for the most major point sources of water pollution (Nasset 1981). Since the Full

Scale Development Option would not entail major point source(s) of water pollution, the EPA would not require an NPDES permit for it either (Nasset 1981).

5.4.2 State of Alaska Agencies

5.4.2.1 Office of the Governor, Division of Policy Development and Planning (DPDP)

A. Jurisdictional Authority

The Coastal Zone Management Act (CZMA) of 1972 (PL 94-370) provides for the protection, restoration, and management of the coastal zone, and includes provisions for coastal states to prepare their own coastal management plans (CMP's). States with a federally approved plan are granted jurisdictional authority to implement the CZMA's goals and provisions. The federally approved Alaska CMP is based on the State of Alaska Coastal Management Act of 1977, which established a program of shared local and State coastal management responsibility. This Act requires local government units or districts in organized areas, such as the North Slope Borough, to develop coastal programs within a specified time period. Since the North Slope Borough's district coastal program has yet to be approved, the coastal program for this area of Alaska is still executed at the State agency level.

The DPDP, as the lead agency for the Alaska CMP, is responsible for reviewing the consistency of State and federal actions with the Alaska CMP. Since a COE permit and other federal authorizations are required for both project options, both probably will also require from the applicant a Certification of Consistency with the Alaska CMP and the DPDP's concurrence therewith (33 CFR 325.2(b)(2)(ii), Wolf 1981). It is the unusual ownership status of the project areas that makes the requirement for DPDP concurrence a probability rather than certainty. State-established guidelines for implementation of the Alaska CMP state that the coastal zone boundary excludes "federal lands." Whether the project areas -- the subsurface estate of which is under federal control -- constitute "federal lands" as defined in these guidelines, is uncertain (Wolf 1981). Nevertheless, the DPDP's concurrence will probably be required in any case because of the "spill over" effect that the project could have on such State lands as adjacent river bottoms (Wolf 1981).

B. Application Requirements

The DPDP requires no application per se. However, the North Slope Borough must submit to the COE, along with its COE permit application, a signed certification ("Certification of Consistency") that the proposed activity will comply with the Alaska CMP. The COE provides the applicant with this certification form, which he then signs and returns.

Contents of the certification are appended to the COE public notice, serving as a separate public notice announcing application for the DPDP's concurrence with the certification.

C. Review Process (Wolf 1981)

The DPDP's review process begins with the COE's distribution of its joint public notice. Copies of this public notice are sent to the DPDP, which in turn routes them to various other State agencies for comment within a twenty-day period. These agencies send their comments to the DPDP, which in turn reviews them and determines whether to concur with or deny the COE applicant's Certification of Consistency. Where the comments of different State agencies conflict, the DPDP attempts first to reconcile such conflicts at the departmental level. If reconciliation at this level is not possible, the Governor reconciles the differences.

When the DPDP reaches its final decision, this decision is incorporated, along with the comments of the various other State agencies, in a letter to the COE representing the Governor's official response to the COE public notice. From the date on which the DPDP receives a copy of the COE public notice, it ordinarily takes approximately 75 days for the DPDP to concur officially with the applicant's Certification of Consistency, where a State Water Quality Certification is also required (as in this case). If the Alaska Department of Environmental Conservation denies a State Water Quality Certification, the DPDP is legally required to deny the Certification of Consistency. If the Alaska Department of Fish and Game denies a Critical Habitat Permit or an Anadromous Fish Protection Permit, the DPDP has the discretionary authority to deny the Certification of Consistency (and usually does so).

D. Fees

No fee requirements are associated with the DPDP's review or approval process.

5.4.2.2 Alaska Department of Environmental Conservation (DEC)

A. State Water Quality Certification

1. Jurisdictional Authority

Section 401 of the Clean Water Act of 1977 (33 U.S.C. 1344) requires any non-federal applicant for a federal license or permit for any activity that may result in the discharge of a pollutant into "waters of the United States" to obtain State certification that such discharge will comply with applicable effluent limitations and water quality standards. Since a COE Section 10/404 permit will be required for both project options, so, too, will a State Water Quality Certification (hereinafter referred to as a "401 Certification") be required for both options (Bateman 1981). The DEC is the State of Alaska agency vested with the authority to issue the 401 Certification.

2. Application Requirements and Review Process (Bateman 1981)

When the COE receives an application for a COE Section 10/404 permit, it customarily forwards to the DEC a copy of this application which in turn serves as an application to the DEC for a 401 Certification. The COE Section 10/404 public notice is published jointly with the DEC, announcing that a 401 Certification from the DEC has also been applied for and soliciting comments for the DEC within a thirty-day comment period. A public hearing may be held at the close of this comment period if the DEC deems one necessary. However, assuming that no EIS is required, the DEC's Fairbanks Office usually makes its recommendation whether to issue or deny a 401 Certification within ten days of the closing date of the public notice comment period, applying the State Water Quality Standards as recited in 18 AAC 70. The Fairbanks Office's recommendation is forwarded to the Deputy Commissioner of the DEC in Juneau, who either issues (or denies) the 401 Certification. From the time a COE public notice is issued, it ordinarily takes 45 days to issue a 401 Certification. A 401 Certification obtained for the construction of a facility is valid for additional federal permits or licenses subsequently required for the operation of the facility.

The 401 Certification is an important prerequisite for the DPDP's Certification of Consistency and the COE's Section 10/404 permit. As noted above, the DPDP cannot sanction a Certification of Consistency unless and until a 401 Certification is issued, and the COE, in turn, cannot issue a Section 10/404 permit until the DPDP sanctions the Certificate of Consistency.

3. Fees

No fee requirements are associated with the DEC's 401 Certification.

B. Wastewater Disposal Permit

1. Jurisdictional Authority

In accordance with 18 AAC 72, any person planning to conduct an operation that results in the disposal of wastewater into or upon the waters or surface of the land of the State or into a publicly operated sewerage system must obtain a Wastewater Disposal Permit from the DEC before the operation begins. "Wastewater" means sewage, waterborne industrial waste, laundry liquid effluent, shower or sink water, or other wastes that are waterborne or in a liquid state (18 AAC 72.100 (27)). "Waters" include marshes, and all other bodies of surface and underground water, that are in the State or under the State's jurisdiction (18 AAC 72.100 (28)). The DEC asserts its jurisdiction within the NPR-A just as it does anywhere else in Alaska (Lowery 1981).

Given the assumptions that no base camp (with its associated sewage, gray water and disposal facilities) would be required, and that the Interim Option would involve no wastewater generation, a Wastewater Disposal Permit would not be required for this option. However, a Wastewater Disposal Permit would likely be required for the Full Scale Development Option if liquid power plant wastes or other liquid wastes are generated and disposed of on-site (which possesses wetlands and other "waters" within the definition of "waters" of the State) (Lowery 1981).

2. Application Requirements

An applicant is required to submit a completed application, (Form 18-106, which is provided by DEC) in duplicate, with descriptions of the process of treatment used and the disposal site. Specific information on operations is detailed in the permit application. Any additional data on the environment and the facility may be required if the DEC so requests. Instructions for completing the "Wastewater Disposal Permit Application" are also included with the application form. Applications should be submitted at least 60 days prior to the proposed commencement of operations.

3. Review Process

Upon receipt of the application, the DEC will issue a public notice in two consecutive issues of a newspaper in the area of the proposed activities. Public comments are accepted up to 30 days after the final public notice. Public hearings are not necessary, but may be held if public interest so demands. Notification of the proposed discharge must be given to the Alaska Department of Fish and Game, Department of Health and Social Services, Department of Commerce and Economic Development, and Department of Natural Resources for their review and comment.

A Wastewater Disposal Permit will be granted upon a finding that the disposal will meet the State Water Quality Standards (18 AAC 70) and the requirements of 18 AAC 72. It ordinarily takes between 45 and 60 days for the DEC to issue a Wastewater Disposal Permit from the time a complete application form is submitted (Lowery 1981).

4. Fees

There are no application or permit fees.

C. Plan Review for Sewerage Systems or Water and Wastewater Treatment Works

1. Jurisdictional Authority

No person may construct, alter, or modify a sewerage system or treatment works or any part of one until detailed engineering reports, plans, and specifications are submitted to the DEC and aproved by the DEC in writing (18 AAC 72.060). "Sewerage system" means pipelines or conduits, pumping stations, and force mains, and all other appurtenant constructions, devices, and appliances used for conducting wastewater to a point of ultimate disposal (18 AAC 72.100 (21)). "Treatment works" means a plant, device, structure, disposal outfall, lagoon, pumping station, incinerator, area devoted to sanitary landfills, or other works installed for the purpose of treating, neutralizing, stabilizing, or disposing of wastewater and sludges resulting therefrom (18 AAC 72.100 (27)).

Since the Interim Option is not expected to result in the generation of wastewater (or sludge), a Plan Review would not be required for it (Lowery 1981). However, a Plan Review would likely be required for the Full Scale Development Option, if liquid power plant wastes or other forms of wastewater are generated on-site (Lowery 1981).

2. Application Requirements and Review Process

No specific application form is required for plan approval. However, the required engineering reports, plans, and specifications must be certified by a professional engineer registered in the State of Alaska before they are submitted to the DEC.

The DEC may, at its discretion, require that the designs for sewerage systems and treatment works in remote areas have a history of successful operation in comparabmu environmental situations. Sewerage systems or treatment works also must be designed to operate successfully under the conditions of seasonal frost or perennial frost encountered in the areas where the construction is proposed.

If any construction or other activity is intended that might render waters of the State inaccessible or uninhabitable for spawning or propagation of salmon, or cause violations of the State Water Quality Standards, the required submission of plans must contain the following information:

- A detailed description of a timetable for the proposed construction or other activity.

- Other information that the DEC requireu]V+ assess the impact of the proposed activity upon the waters.

The DEC will generally within two to three weeks of receipt of complete plans, approve such plans (Lowery 1981), provided the applicant demonstrates that the sewerage system or treatment works will meet the requirements of 18 AAC 72.060 (Plan Review) and State Water Quality Standards. The DEC may attach terms and conditions to approved plans necessary to insure compliance with such requirements and Standards.

For the purpose of reviewing plans, the DEC will use, where applicable, the design criteria contained in the following:

- Sewage Treatment Plant Design, Manual of Practice No. 8, 1976, and Design and Construction of Sanitary and Storm Sewers, Manual of Practice No. 9, 1970; Water Pollution Control Federation, 3900 Wisconsin Avenue, Washington, D.C. 20016.

- o Glossary--Water and Wastewater Control Engineering, Joint Editorial Board, American Public Health Association, American Society of Civil Engineers, American Water Works Association and Water Pollution Control Federation, 1969; available from Water Pollution Control Federation, 3900 Wisconsin Avenue, Washington, D.C. 20016.
- o Wastewater Engineering: Collection, Treatment, Disposal, Metcalf and Eddy, Inc., 1972, McGraw-Hill Book Company, New York, New York.
- o Recommended Standards for Sewerage Works, Great Lakes -- Upper Mississippi River Board of State Sanitary Engineers, Health Education Service, P.O. Box 7283, Albany, New York, 12224.

(Copies of the materials referenced above are on file in the Lieutenant Governor's Office and may be reviewed in any of the regional offices of the DEC.)

3. Fees

No fees are required for the Plan Review or approval.

D. Solid Waste Disposal Permit

1. Jurisdictional Authority

In accordance with 18 AAC 60, any person planning to establish, modify, or operate a solid waste disposal facility must obtain from the DEC a Solid Waste Management Permit, with several exceptions. However, the only exception to this permit requirement that is even remotely applicable to this project is incinerator facilities having a total rated capacity of less than 200 pounds of solid waste per hour (18 AAC 60.020(3)). "Solid waste" is defined to include mine wastes, gravel pit and quarry spoils, and overburden except that orginating from the construction of single buildings (18 AAC 60.130(15)). "Solid waste disposal facility" means an intermediate disposal facility, transfer station, landfill, incinerator, composting plant, recycling or reclamation facility or any site utilized for the reduction, consolidation, conversion, processing, or disposal of solid waste (18 AAC 60.130(16)). As noted above, the DEC asserts its jurisdiction within the NPR-A just as it does anywhere else in Alaska (Lowery 1981).

A Solid Waste Disposal Permit is likely to be required for both the Interim and Full Scale Development Options, if the solid mine wastes (e.g., overburden) to be generated thereby are to be disposed of and/or processed on-site.

2. Application Requirements

An applicant is required to submit two completed "Waste Disposal Permit Application For Solid Waste Management Activities" forms (no form number available) showing:

a. Detailed plans and specifications for the facility (18 AAC 60.020(b)(2)).

b. Certification of compliance wtih local ordinances and zoning requirments (18 AAC 60.020(b)(3)).

c. A report detailing the proposed method of operation, population and area to be served, the characteristics, quantity and source of material to be processed, the use and distribution of processed materials, method of residue disposal, emergency operating procedures, the type and amount of equipment to be provided, and the proposed ultimate land use (18 AAC 60.020(b)(4)).

Applications should be submitted at least 60 days prior to the proposed commencement of operations.

3. Review Process

Upon the receipt of an application, the DEC will publish a public notice in two consecutive editions of a newspaper in the area of the proposed activities. Public comments are accepted up to 30 days following the final notice. Public hearings are not mandatory unless dictated by public comment. Copies of the Solid Waste Disposal Permit application are sent to the Alaska Departments of Fish and Game, Health and Social Services, Commerce and Economic Development, and Natural Resources for their review and comment.

The DEC will issue a Solid Waste Disposal Permit if the applicant demonstrates that the disposal facility meets the requirements of 18 AAC 50, 18 AAC 60, 18 AAC 70, and 18 AAC 72, and that the establishment or continued operation of the disposal facility will not result in avoidable proliferation of such facilities in the affected area (18 AAC 60.020(h)).

At the end of the 30-day public notice period, the DEC may act on the application. It ordinarily takes between 45 and 60 days for the DEC to issue a Solid Waste Disposal Permit from the time a complete application form is submitted (Lowery 1981).

4. Fees

There are no application or permit fees.

E. Air Quality Control Permit to Operate

18 AAC 50.300 requires a Permit to Operate for certain point sources and levels of air pollution emissions. Since the only foreseeable source of emissions generated by the Interim Option would be fugitive dust, a non-point source, a Permit to Operate would not be required for this option. However, the Interim Option would still be subject to the DEC emission standard requiring the "taking [of] reasonable precautions to prevent particulate matter from becoming airborne" (18 AAC 50.050(e)).

Besides generating fugitive dust from mining operations subject to the above-mentioned emission standards, the Full Scale Development Option would also entail the construction either of low pressure coal-fired water heaters or coal-fired steam turbines for the generation of electricity -- all point sources of air pollution emissions. As noted in Section 5.2.1.1 of this chapter, design of these facilities would be the same as that of one of two recommended alternatives referenced in the July 1980 feasibility study entitled, Wainwright Central District Heating System: Alternative A-II (low pressure coal-fired water heaters), with a rating of approximately 21 million Btu/hour, and Alternative A-1 (coal-fired steam turbines), with a rating of approximately 31 million Btu/hour. The applicability of permitting requirements to each alternative, pursuant to 18 AAC 50.300, is discussed below:

The ratings of both Alternatives A-1 and A-II are less than the 50 million Btu/hour threshold (18 AAC 50.300(a)(1)(B)) above which a Permit to Operate is required for any fuel burning equipment that also requires an air contaminant emission control unit or system to comply with State emission standards (18 AAC 50.040 through 18 AAC 50.060). Hence, neither alternative will require a Permit to Operate, although they must still meet these State emissions standards, as applicable (Hungerford 1981). The following emissions standards are applicable to both alternatives:

- Visible emissions, excluding condensed water vapor, from fuel burning equipment may not result in a reduction of visibility through the exhaust effluent of greater than twenty percent for a period or periods aggregating more than three minutes in any one hour (18 AAC 50.050(a)(1)).

- Particulate matter emitted from fuel burning equipment may not exceed, per cubic foot of exhaust gas corrected to standard conditions, 0.5 grains (Alternative A-II) (18 AAC 50.050(b)(1)), or 0.1 grains for steam generating plants burning as fuel coal and rated less than 250 million Btu/hour heat input (Alternative A-1) (18 AAC 50.050(b)(2)(B)).

- Sulfur compound emissions from fuel burning equipment, expressed as SO?2? and averaged over a period of three hours, may not exceed 500 pmm (18 AAC 50.050(d)).

- No person may cause or permit bulk materials to be handled, transported, or stored, or engage in an industrial activity or construction project without taking reasonable precautions to prevent particulate matter from becoming airborne (18 AAC 50.050(e)).

F. Alaska Master Application

1. Jurisdictional Authority and Purpose

Under AS 46.35, an applicant may request the DEC to process a "Master Application" for all the State permits required for a project. This program is aimed primarily at large or complex projects requiring numerous permits and approvals and theoretically provides for an instantaneous, streamlined processing of all required State applications. Public notices and hearings, if necessary, are conducted jointly. Master Application forms may be obtained at any Alaska Permit Information Center or local DEC office.

2. Review Process and Associated Fees

a. Upon receipt of the Master Application at a State Permit Information Center, the following steps are taken:

- Copies of the Master Application and the site diagram are sent for review to all State departments and any municipality where the project is located. A statement is requested regarding agency jurisdiction and any permits that may be required for the proposed project.
- The above agencies must respond to the Permit Information Center within fifteen days. If the agencies have any jurisdiction over the project and require a permit, they will submit their individual application forms to the Permit Information Center with a statement as to whether a hearing is required.
- The Permit Information Center sends the individual application form to the applicant for completion. Completed applications and required fees are returned to the Permit Information Center, which in turn forwards them to the appropriate agencies.

- The Permit Information Center makes the arrangements for a public hearing on the project, if a hearing is required. Within 30 days of receipt of the last applications, the Permit Information Center publishes a notice once a week for three consecutive weeks. The applicant is required to pay for the cost of publication.

- The public hearing is held in or near the municipality where the major part of the proposed project is located. This hearing is held within 20 to 30 days of the last publication of the notice. Members of the public and the applicant may be present. Any State agency that requires a permit for the project shall be represented at the hearing.

- At the close of the hearing, the chairperson establishes a date (within 90 days form the hearing date) for the final decisions on all project applications. The final decisions will be submitted to the DEC, which incorporates them into one document and submits them to the applicant personally or by certified mail.

3. Efficacy of Master Application Process

No formal "tracking record" has been established comparing how long it actually takes, with and without the Master Application process, to obtain all the necessary State authorizations for two comparable projects (Hughes 1981). However, in the two years since this process' inception, the DEC's Fairbanks office has seen a total of only eight

Master Applications (Hughes 1981), and a staff member at the DEC's Juneau office has seen only one (Hungarford 1981). It is felt by some that, while the Master Application is a well-intended reform of the lengthy permitting process, it is ineffective in practice because of the inordinate amounts of time and energy that it requires of the DEC to coordinate and process it.

In any case, the Master Application process is likely to be changed in early 1982, when the Alaska State Legislature is expected to amend State laws governing the processing of State permit applications (Wolf 1981).

5.4.2.3 Alaska Department of Fish and Game (DF&G)

Under Title 16 of Alaska Statutes, the DF&G requires an Anadromous Fish Protection Permit for activities that could affect designated anadromous fish rivers, lakes, and streams and a Critical Habitat Permit for activities to occur within established critical habitat areas. However, no established critical habitat areas, as defined in AS 16.20.230, encompass any of the project areas, and the only designated anadromous fish waterway in the project vicinity is the Kuk River, situated adjacent to Area C (Milke 1981). As noted above, it is assumed that the project would not entail any activity affecting the Kuk River. Hence, so long as this assumption holds, no permits are required from the DF&G (Milke 1981).

Nevertheless, while the DF&G has no jurisdiction to require any permits for the project, its advisory powers could be considerable. As mentioned above, Executive Order 11574 requires the COE to coordinate with State fish and wildlife agencies throughout its Section 10/404 permit process. Part of the COE's coordination with the DF&G entails the routing of the COE public notice to the DF&G for comment. Wherethe DF&G recommends that certain stipulations be attached to the COE permit in order to avoid or to mitigate adverse impacts to fisheries, the COE usually incorporates such stipulations in its permit (Milke 1981).

The DF&G has already expressed the following comments on the project, portions of which comments are likely to be embodied in its response letter to any future COE public notice, depending upon which final project area is selected before application is made to the COE: Project Area A-B would probably be environmentally preferable, since it is located within a mile of Wainwright, thereby minimizing access road requirements and localizing disturbances.

> Project development in . . . Area C probably has the greatest potential for adverse impacts to fish and wildlife. This site is the farthest removed from Wainwright, which would necessitate a relatively long access road. Summer road traffic and project activities could disturb shorebird nesting and waterfowl nesting, moulting, and staging. The area is intensively used by black brant, old squaw, and eider during late summer and fall for moulting and staging. Activities

> could also impact spotted seals, which commonly haul out at various locations along the Kuk River during the summer and fall.
>
> Also, the Kuk River supports grayling, least cisco, boreal smelt, ninespine stickleback, and fourhorn sculpin . . . . Area C is located adjacent to the river, and any discharges into the watercourse could impact the fish populations (Milke 1981).

Should Area C be chosen as the area from which the final project site is selected, it is conceivable that the DF&G would recommend, and that the COE would adopt, certain stipulations in the COE permit to mitigate any foreseeable adverse impacts there. On the other hand, selection of a final project site from within the preferred Area A-B should minimize DF&G concerns.

5.5 Summary: Critical Path Diagrams

The two critical path diagrams that follow this discussion (Figures 5.2 and 5.3) summarize the necessary environmental authorization and the minimum processing time associated therewith. As shown in these diagrams, if the OSM requires a Surface Coal Mining and Reclamation Operations Permit, it will take approximately one year from the time all the necessary applications are submitted to obtain all authorizations required for both project options. If the OSM does not require a permit, this time frame can be halved, with the COE Section 10/404 Permit then requiring the most time to secure.

The filing of a COE permit application automatically triggers the Alaska DEC's State Water Quality Certification process and the Alaska DPDP's Certification of Consistency process; thus, no separate applications are required for either of these two authorizations. The diagrams also indicate that, if the Full Scale Development Option is selected, the North Slope Borough should simultaneously file with the Alaska DEC applications for a Plan Review Sewerage Systems or Water and Wastewater Treatment Works and for Wastewater and Solid Waste Disposal Permits, in order to insure concurrent and expeditious processing. If the Borough pursues the Interim Option and needs to obtain gravel or other mineral materials from an as-yet unauthorized site, the Borough should simultaneously apply to the BLM for a Free Use Permit for Disposal of Mineral Materials and a License to Mine, also in order to insure concurrent and rapid processing.

The following steps will also assist in controlling the regulatory time frame. Although these steps may not reduce the time periods from those depicted in the critical path diagrams, their use will help to ensure that these time periods do not lengthen.

- A pre-application conference with all potential regulatory agencies is extremely useful in identifying possible agency concerns. The conference can also provide vital insights into areas of the applications that should be emphasized, studies that may be required, and how such studies should be conducted to arrive at the level of detail sufficient for agency decision making.

- Submission of an application that is thorough and complete also facilitates the permitting process. Significant delays can occur if, at the end of its review process, an agency requests additional information or determines that the application is inadequate in some manner.

- Close personal contact should be maintained throughout the permitting process with each of the major agencies. A continuing demonstration of interest in expediting the process and the establishment of a close working relationship with agency personnel can be quite effective. The intent should be to establish informal lines of communication that can be used to provide additional information or to answer questions, rather than formal lines of communication that can require weeks rather than hours for the simplest of exchanges.

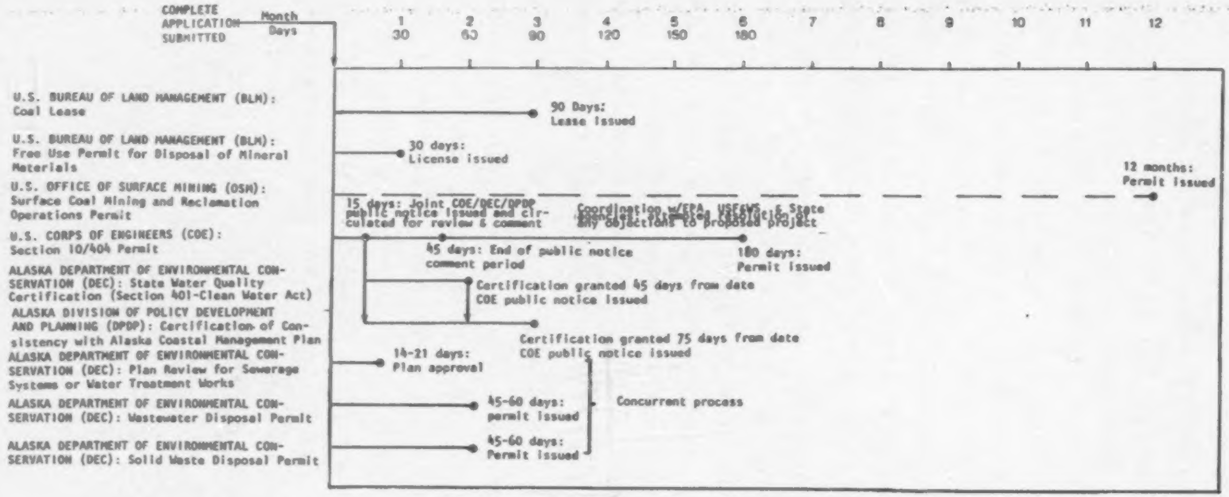
5.6 Additional Studies Recommended

Should the U.S. Office of Surface Mining require a Surface Coal Mining and Reclamation Operations Permit for either project option, extensive environmental and geotechnical studies would have to be undertaken as a part of permit application requirements. Among the information that would need to be gathered are detailed geological data (including test borings and coal samples, unless exploratory operations conducted by ASTS in July, 1981 are sufficient); hydrological, climatological, vegetative, soil resource, fugitive dust control and land use (including haul road construction) information; a fish and wildlife study for the mine plan area; extensive site mapping; plans for mine operation, minimization of impacts on fish and wildlife, mine site reclamation, and water control; and descriptions of spoil disposal sites and methods (requiring a geotechnical site investigation) and transportation means to, from, and within the permit area.

The above information is required irrespective of whether the mine will be surface or subsurface in nature. If the mine were to be a surface mine, a blasting plan would need to be submitted in addition to the information cited above. (For a more detailed discussion of the above informational requirements, please see pages 5-14 through 5-26 of this section).

If Alternative A-1 (coal-fired boilers connected with electricity-generating steam turbines) of the Full Scale Development Option is chosen, a detailed engineering report would have to be submitted to the Alaska Department of Environmental Conservation before they could issue an Air Quality Control Permit to Operate (see pages 5-53 through 5-56 of this section for more details).

WAINWRIGHT REGULATORY PROCESS: FULL SCALE DEVELOPMENT OPTION

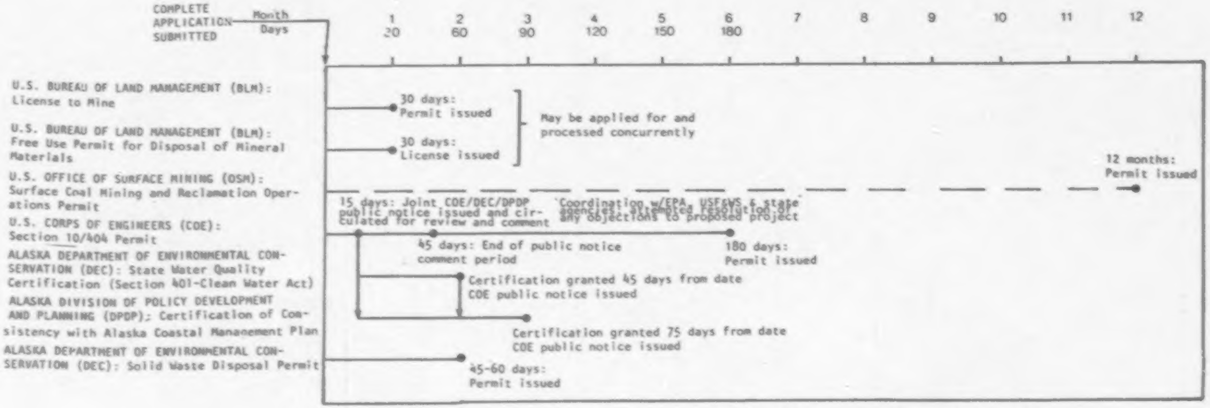


NOTE: Authorizations that are likely to be required, as well as those that will definitely be required, are shown in this chart. Where a dashed horizontal line is used in lieu of a solid horizontal line, the likelihood of the agency requiring the authorization represented thereby is uncertain.

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY
11-81

FIGURE 5-2: Regulatory Process: Full Scale Development Option

WAINWRIGHT REGULATORY PROCESS: INTERIM OPTION


COMPLETE APPLICATION SUBMITTED
Month
Days
1 20
2 60
3 90
4 120
5 150
6 180
7
8
9
10
11
12
U.S. BUREAU OF LAND MANAGEMENT (BLM): License to Mine
U.S. BUREAU OF LAND MANAGEMENT (BLM): Free Use Permit for Disposal of Mineral Materials
U.S. OFFICE OF SURFACE MINING (OSM): Surface Coal Mining and Reclamation Operations Permit
U.S. CORPS OF ENGINEERS (COE): Section 10/404 Permit
ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION (DEC): State Water Quality Certification (Section 401-Clean Water Act)
ALASKA DIVISION OF POLICY DEVELOPMENT AND PLANNING (DPDP): Certification of Consistency with Alaska Coastal Management Plan
ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION (DEC): Solid Waste Disposal Permit
30 days: Permit issued
30 days: License issued
May be applied for and processed concurrently
12 months: Permit issued
15 days: Joint COE/DEC/DPDP public notice issued and circulated for review and comment
Coordination w/EPA, USF&WS & state agencies; attempted resolution of any objections to proposed project
45 days: End of public notice comment period
180 days: Permit issued
Certification granted 45 days from date COE public notice issued
Certification granted 75 days from date COE public notice issued
45-60 days: Permit issued

NOTE: Authorizations that are likely to be required, as well as those that will definitely be required, are shown in this chart. Where a dashed horizontal line is used in lieu of a solid horizontal line, the likelihood of the agency requiring the authorization represented thereby is uncertain.

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 5-3: Regulatory Process: Interim Option

PARTIAL LIST OF REFERENCES (EXCLUDING LAWS AND REGULATIONS)

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6.0 MINE-MOUTH GENERATION

The question of whether electrical generation and/or heating fluid reheating should take place at the mine mouth or at a location close to Wainwright has resolved itself by virtue of the fact, that the preferred mine location happens to be close to Wainwright.

On account of residual stack emissions and a certain unavoidable incidence of coal dust, one would in any event propose siting a coalhandling and firing facility no closer than 1/2 mile from the village, and 1/2 mile happens to be the distance of the preferred site from the village.

We have been informed by Mr. Leonard F. Nelson, engineering geologist with NSB, that it is proposed to construct a road from Wainwright village along the bluff overlooking the Wainwright Inlet (Kuk River) to a point about 2 miles short of drill area C, which is situated near the bank of the Kuk River about 8 miles South of Wainwright. In spite of this, drill area A-B close to Wainwright is still the preferred mine-site, for economic reasons alone. Aside from this the A-B site is more conveniently situated as a place to work.

If the mine were located at drill-area C, the incline would be somewhat shorter at a saving of around $150,000. On the other hand, an additional two miles of road and a creek crossing would have to be constructed offsetting the above saving. In addition an 800 KW diesel generator would have to be provided. The capital cost would be further increased by the provision of a loader and a tipper truck since the mine haulers do not have the capacity nor are they suited for road haulage.

Altogether, the additional capital cost will be of the order of $1,000,000. The cost of transporting the coal from drill area C to a low-pressure boiler facility near the village would be in the order of $10.50 per ton which would have to be added to the minemouth cost calculated for drill area A-B.

Servicing of the additional capital will cost in the order of $80,000 per year which for a 10,000 ton production means additionally $8.00 per ton for a 5,000 ton production $16.00 per ton.

The total extra cost of mining at drill area C would thus come to $18.50 per ton at 10,000 tons per annum and to $26.50 per ton at 5,000 tons per annum.

7.0 RECOMMENDATION AS TO MINE LOCATION AND MINING METHOD

Having regard to the considerations mentioned in Section 6.0; it is recommended that mining takes place in drill area A-B 1/2 mile Northeast of Wainwright and that underground mining is carried out as described in Section 4.0.

8.0 ORGANIC RANKINE CYCLE GENERATION

8.0.1 General Remarks

The purpose of this part of the subject extension study is to investigate the suitability of Organic Rankine Cycle (ORC) electric generation in conjunction with a coal-fired liquid medium central heating system.

One of the alternatives recommended for further study in the initial feasibility study was alternative A-II, which relies on low-pressure coal-fired heaters for reheating the liquid medium used for space heating. This alternative provided for electric power to be generated by existing diesel electric generators.

The Utilities Department of the N.S.B. has expressed concern about a continued reliance on imported fuel oil for power generation and has requested that ORC-generation using coal as the prime energy source be investigated as an alternative to continued reliance on diesel generators to cover electric demand.

Energy for the ORC-generators would be provided by a liquid medium with a temperature of 210°F heated in coal-fired low pressure heaters, the latter being of sufficient capacity to supply both electric and heating needs.

8.02 SUMMARY AND RECOMMENDATIONS

8.02.1 Summary

Annual costs were calculated for three makes of ORC machines on a similar basis to those given for Alternate A-II on Page 62 of the Initial Feasibility Study. The annual costs were based on prices given to us by equipment suppliers and on capital costs used in the Initial Feasibility Study on Page 54, increased where it seemed appropriate for changed conditions.

The Ormat design has a good experience background, but its low price is offset by low efficiency and low net capability. The Rotoflow design has high efficiency, but this is off set by high price, the complication of a two-stage unit and the use of an inflammable fluid at over 500 psig as the working medium. The Mafi-Trench design is similar to Ormat's but their claimed efficiency is higher. Both Rotoflow and Mafi-Trench have had much less experience in package units.

Cost calculations were made for various alternatives as shown in Sections 8.05.3.1 to 8.05.3.7., using two scenarios. Scenario A deals with the current situation, using the current cost of diesel fuel and the cost of coal forecast as a result of the completed mining study. Scenario III is one also used in the initial study and assumes hypothetical future costs of $ 5 per gallon for diesel fuel and $120 per ton for coal. Apart from the interim case, where bagged coal is used for direct home heating, alternative A-II shows the best economy in both scenarios. Of the three ORC makes, Rotoflow comes out best from the point of view of economy, but it is possible that Ormats greater experience with packaged units outweighs the difference in economy.

8.02.2 Recommendations

It is recommended that ORC generation not be considered at this time because of its very high capital cost, $1,179 to $3,450 per KW, and low efficiencies, 8% to 14% for this application, both factors contributing to a high annual cost. Also, the experience background of ORC generation is very limited compared to that of Diesel, and therefore, there would be more risk involved with ORC.

It is considered that conditions might change to make ORC generation desirable at some future time, consequently space might be provided to accommodate these machines, their auxiliaries, and the necessary additional boiler capacity and coal handling equipment.

8.03 BASIS OF STUDY

8.03.1 Temperature and Pressure Levels

The study was based on the operation of the heating system at a maximum temperature of 210°F with the idea of operating the boilers at 15 pounds per square inch gauge or less. This pressure would be maintained on the heating liquid being circulated through the village by nitrogen gas above the liquid in the expansion tank as shown in Figure 8.1, "Study Flow Diagram." Higher pressures would allow operation of the system at higher temperatures, but resultant disadvantages do not, in our opinion, justify the accompanying advantages of higher operating efficiency of the ORC generators.

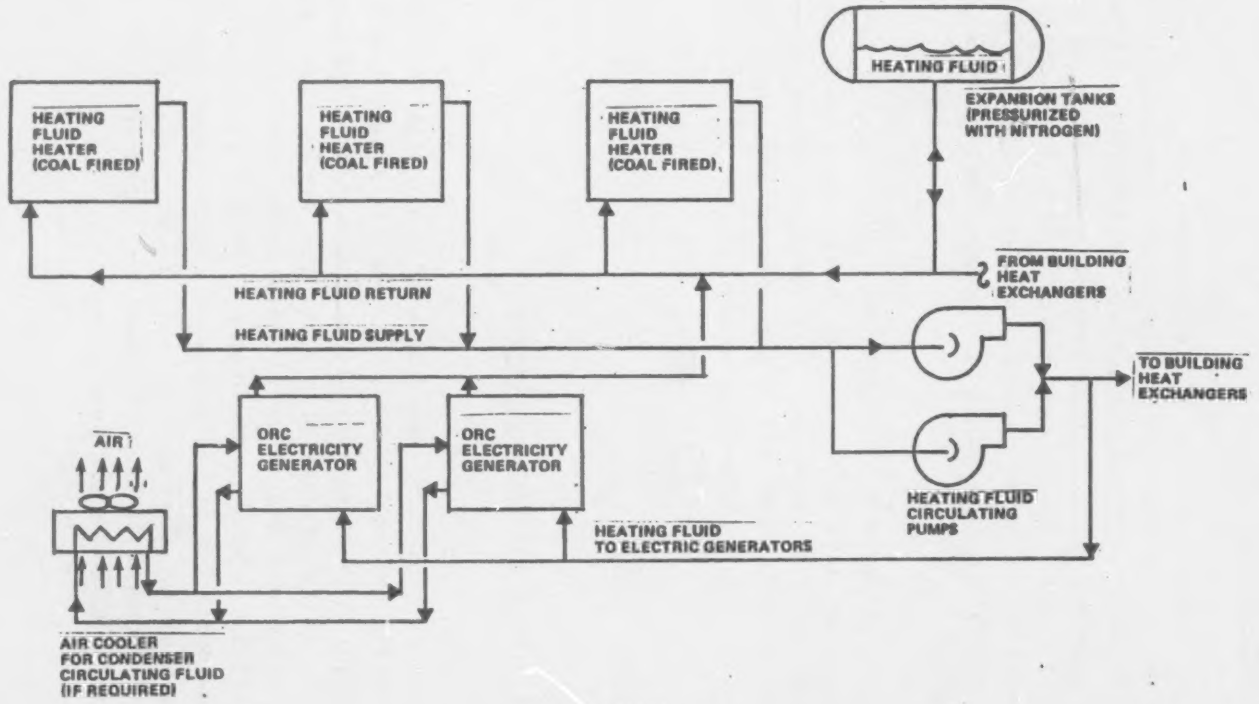
HEATING FLUID
HEATING FLUID HEATER (COAL FIRED)
HEATING FLUID HEATER (COAL FIRED)
HEATING FLUID HEATER (COAL FIRED)
EXPANSION TANKS (PRESSURIZED WITH NITROGEN)
FROM BUILDING HEAT EXCHANGERS
HEATING FLUID RETURN
HEATING FLUID SUPPLY
TO BUILDING HEAT EXCHANGERS
AIR
ORC ELECTRICITY GENERATOR
ORC ELECTRICITY GENERATOR
HEATING FLUID CIRCULATING PUMPS
HEATING FLUID TO ELECTRIC GENERATORS
AIR COOLER FOR CONDENSER CIRCULATING FLUID (IF REQUIRED)

FIGURE 8.1

WAINWRIGHT CENTRAL DISTRICT HEATING WITH ORC ELECTRICITY GENERATION
STUDY FLOW DIAGRAM
ALTERNATE A-II-A

The principal disadvantages of high temperature operation would be reduced safety, not only in the boiler and generator house, but also in all the homes and other buildings served by the heating system because of the increased probability of leaks and burn injuries. For example, operating the system at a temperature of 250 F would require an operating pressure of about 20 psi gage (lo psi above the saturation pressure of 10 psi gage). +) A temperature of 300 F would require an operating pressure of about 55 psi gage. Hazards of high temperature hot water in homes and shops can be avoided by providing a heat exchanger at each point of use, each with a separate low pressure circulating system including pump and expansion tank. This additional equipment would greatly increase the cost of the heating system and would complicate its operation, both by the plant operators and by the individual users.

A further complication of high temperature heating is the likelihood that the State of Alaska would require licensing of plant operators.

Mr. R.D. Cather, Chief Engineer, Pressure Vessel Division, State of Alaska, was contacted by telephone on this matter. He said that the State does not require operating licenses of heating boilers at present, nor would continuous presence of operators be required if proper automatic controls were applied. We believe that this could change if heating boilers are operated at high temperatures.

Further, the two most competitive ORC generator manufacturers, Rotoflow and Mafi-trench were reluctant to work up designs for more than one liquid supply temperature

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+) glycol/water mixture

because different temperatures usually require different working fluids. Therefore, it was agreed that one temperature, 210 F would be acceptable. In the meantime, however, all our correspondence with Ormat has been on the basis of 248 F supply temperature. So their proposal was based on 248 F. Discussion with other manufacturers indicated that reducing supply temperature from 248 F to 210 F would cause a loss of efficiency of less than 2 percentage points.

8.03.2 Capital Costs

In line with "Capital Costs" of page 50, Section 7.01 of the feasibility study of July 31, 1980, capital costs of new equipment were figured on a 1980 basis in order to be comparable. The costs of new boilers were calculated at 80% of the 1981 costs on the advice of a representative of the boiler company. Costs of the ORC generators, however, were not adjusted because the ongoing developments in this field make it difficult to estimate what a new design would have cost a year ago.

8.03.3 Number of Units Proposed

Because of back-up from the existing Diesel plant and because ORC generator is comparatively new, we considered purchased only two 300 KW machines initially.

8.03.4 Annual Costs

Annual costs were based on heating and electric load requirements as of December 31, 1982 (Initial Feasibility Study, Page 13, Section 3.02).

8.04 DESCRIPTION OF ORC SYSTEMS INVESTIGATED

8.04.1 General

As illustrated and described in Figure 8.2, the Organic Rankine Cycle (ORC) generator is a relatively simple machine usually furnished as a packaged unit. Figure 8.2 is taken from an Ormat brochure and shows a liquid cooled condenser. The liquid is cooled by circulating it through a separate cooler. Circulating pump and separate cooler are not shown. Many other makes of ORC generators use a direct air cooled condenser which is part of the package.

The text of Figure 8.2 refers to an electric generator being connected to a synchronized grid; in other words, an induction type generator. At Wainwright, however, there is no frequency-regulated electric grid so the ORC generators will have to be of the synchronous type and governors will have to be provided on the prime movers, similar to the Diesel generators operating there.

Figure 8.3, "Comparison of Responsive ORC Manufacturers" is a tabulation of the salient features of the offerings made by Ormat, Rotoflow, and Mafi-Trench. Other companies in this field contacted had no designs to match our needs and did not seem to be interested in this project.

8.04.2 Ormat Turbines Ltd.

Ormat Turbines, Ltd. of Yavne, Israel is probably the most experienced firm manufacturing ORC generators. They are represented in the USA by Swenson Division of Whiting Corporation, Harvey, Illinois. We had been in touch with these people since last September and wrote them March 27, 1981 asking for more specific information. Receiving

FIGURE 8.2

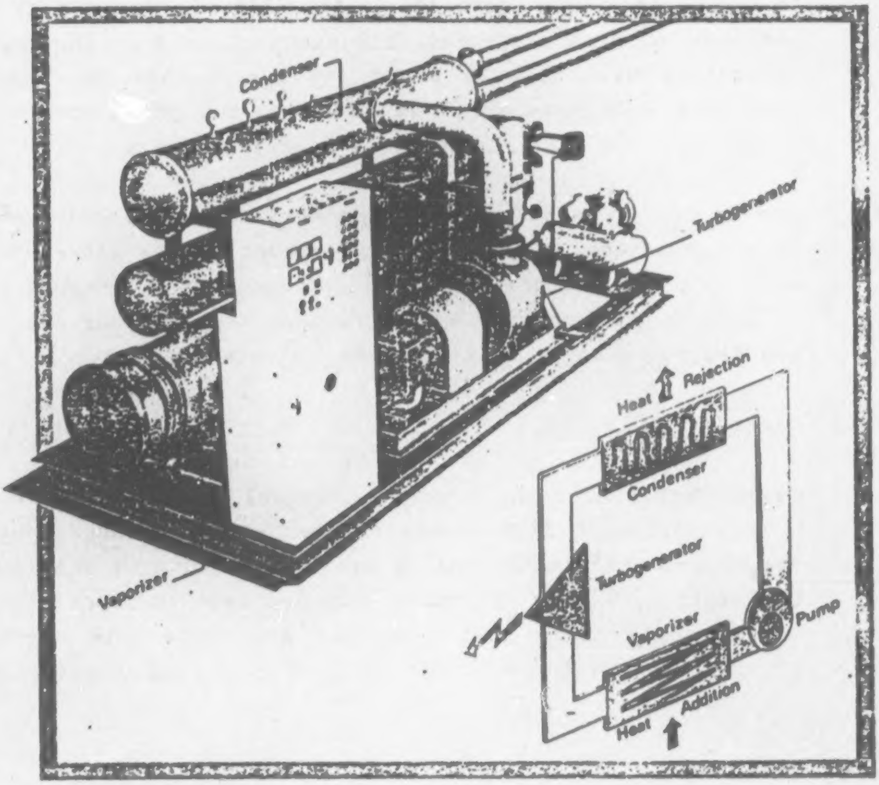
How the Ormat Energy Converter Works

The ORMAT Energy Converter (OEC) is a self-contained, fully automatic equipment package.

Like the steam turbine, the system is based on the Rankine power cycle but uses the advantages that an organic working fluid has at low temperatures. Properly selected organic fluids result in the use of smaller, more efficient turbines, eliminate the need for superheaters, and permit the application of sealed units, similar to refrigeration compressors, which require little maintenance other than periodic cleaning of heat exchanger surfaces.

The working fluid is vaporized by the waste heat in a vaporizer or boiler, specially selected for your waste heat stream. The pressurized vapor expands through a uniquelly selected, organic vapor turbine which is direct coupled to a generator producing conditioned, grid synchronized electric power. The low pressure turbine exhaust is condensed in a surface type condenser and the condensed fluid is pumped to the vaporizer by the feed pump.

The system is normally operated in parallel with the process stream and fully regulated, with a control system designed to maintain the integrity of your process.



no reply, we phoned them on May 4, 1981 and learned that their contract with Ormat restricts them to waste heat applications. This required us to deal directly with the factory in Israel, but it also made it possible to purchase their equipment outright instead of on a monthly leasing contract under which Whiting Corp. would have participated in the savings attributable to the unit.

We sent a telex to Ormat Israel May 8, 1981 requesting detailed information, following up with another telex on June 4th and a letter on June 11th. The information requested arrived by telex June 21, 1981. Unfortunately, it was based on 248°F liquid inlet temperature and induction type generators. As of July 24, 1981, Ormat has not responded to the more detailed request for information contained in our June 11th letter.

The Ormat Turbines uses Freon 12 as the working fluid, which is relatively safe, and readily available. Maximum working pressure, based on data from Mafi-Trench would be about 300 psig.

As mentioned in 8.04.1 above, the Ormat units require separate condenser cooling equipment which is not included as part of their package. Because of the difficulty of communicating with them, we have not yet received complete information on their cooling requirements. On the basis of the information we do have, however, we obtained estimates from two cooling apparatus manufacturers and used the lower of the two. The cooling apparatus not only significantly increases the capital costs of the Ormat machine, it also uses a substantial amount of electricity, thereby increasing operating costs and reducing net capability.

8.04.3 Rotoflow Corporation

Rotoflow Corporation of Los Angeles, California are the second oldest of the three responsive manufacturers. Usually they furnish only the turbine-generator, coupled together through a reduction gear. For this project, however, they are proposing to furnish complete packages, consisting of turbine-expander (which they manufacture), reduction gear, synchronous generator, exciter, Woodward governor, lube oil pump, feed pump, evaporator-boiler, air fan condenser; everything needed except electrical switch-gear. Packages will be assembled on steel skids.

Rotoflow proposes compound machines each 300 KW unit consisting of a high pressure turbine generator of about 150 KW and a low pressure turbine generator of about 150 KW which receives the exhaust of the high pressure turbine. This arrangement provides better efficiency by allowing an overall greater pressure drop of the working fluid.

The high pressure stage would exhaust at 68 F, the low pressure at -34 F. This means that full capability of the two stage machines would be possible only at outdoor temperature below about -45 F. At 0° outdoors, capability would be cut about one-third. Efficiency would also be reduced somewhat. During the summer, when electric loads are light, the low pressure machines could be shut down. Working fluid would be propylene with a working pressure of 525 psig at rated load.

8.04.4 Mafi-Trench Corporation

Mafi-Trench Corporation of Westlake Village, California (a suburb of Los Angeles) usually furnish only the turbine, reduction gear and generator with lube oil pump. For this project, however, they propose to furnish two complete packages, including air-cooled condensers, assembled on steel skids. Switchgear and motor starters are not included in their package.

Mafi-Trench offers 2 machines, single stage, similar to the Ormat units. Also, like the Ormat, they would use Freon 12 as the working fluid, but the condensers would include air fan coolers similar to those of Rotoflow. Their package would be on 6 skids. Switchgear is included in their price.

8.04.5 Barber-Nichols Engineering Company

Barber-Nichols Engineering Company, Arvada, Colorado, was sent a letter dated April 2, 1981. No reply having been received, they were contacted by telephone on May 11, 1981. We were told that they were busy and had no designs in the neighborhood of 300 KW size, but could design one to sell between $300,000 and $400,000. Being already in touch with two companies in Los Angeles offering machines at lower prices, we did not ask them to work up a design. We later learned that these machines lacked boilers, condensers, and auxiliaries.

8.04.6 Mechanical Technology, Inc.

Mechanical Technology, Inc. (MTI), Schenectady, N.Y., has a 300 KW machine under development, but Mr. Don Elbert, MTI local representative, thought that it would cost about $2,500,000 and they had no definite schedule for manufacture.

8.04.7 Sundstrand Corporation

Sundstrand Corporation, Rockford, Ill's local representative, Mr. Burdette Olthoff, said that their machine is 750 KW in size, uses toluene as the working fluid and does not operate well at inlet heat supply temperatures lower than 600 F.; so this machine could not fit our needs at all.

8.05 COSTS

8.05.1 General Remarks

Capital costs of ORC equipment were calculated based on information received from the three responsive manufacturers. These costs are included in Figure 8.3, "Comparison of Responsive ORC Manufacturers." Estimated costs of switchgear were added to make ORC costs comparable with existing Diesel plant costs.

Additional costs were needed for the Ormat machines because they would be shipped from Israel and require separate condenser cooling equipment. This additional equipment requires additional energy which has to be deducted from the Ormat generator output. On the other hand, Ormat included two weeks of free service (Rotoflow and Mafi-Trench did not); so estimated costs of this service were added to Rotoflow and Mafi-Trench's figures.

Annual costs were calculated on the basis of data given in the Initial Feasibility Study for 1982.

FIGURE 8.3

COMPARISON OF RESPONSIVE ORC MANUFACTURERS

		ORMAT	ROTOFLOW	MAFI-TRENCH
1.	Factory Location and FOB Point	Israel	Los Angeles	Westlake Vlg. CA
2.	Simple or Compound Cycle	Simple	Compound	Simple
3.	Nominal Output, Kilowatts	300	170 + 180	335
4.	Condenser Cooling Meduim	Liquid	Air	Air
5.	Extra Auxiliary Power, KW	40	50	70
6.	Net Output, KW each	260	300	265
7.	Max Air Temp. for 1st Stage Condenser Cooling	Not Applic.	-35 F.	Not Applic.
8.	Working Fluid	Freon 12	Propylene	Freon 12
9.	Overall Net Efficiency for 210 F. Inlet Fluid	8.0% approx.	13.5%	10% approx.
10.	Generator Type	Induction	Synchronous	Synchronous
11.	Estim. Extra for Sync. Gen. and Governor, 2 Machines	$40,000	Included	Included
12.	F.O.B. Price for 2 Machines	$768,500	$2,024,300	$1,673,590
13.	Extra Shipping Cost	$8,000	———	———
14.	Separate Cooler and Cir. Pumps	$177,200	Not Needed	Not Needed
15.	Two-weeks' Service-Estimate	Included	$20,000	$20,000
16.	Quote Valid Until	8-31-81	———	———
17.	Shipment	8-10 Mos.	10 Mos.	Not Stated
18.	Switchgear Estimated Cost	$27,930	$29,660	Included
19.	Total Estimated Cost, F.O.B., L.A.	$1,021,630	$2,070,960	$1,693,590
20.	Cost Per Net KW	$1,970	$3,450	$3,160

8.05.3 Annual Costs Summary

In the following pages calculations of total annual costs for various alternatives are shown, as summarized hereunder:

Scenario	A	III
Diesel fuel oil per gallon	$ 2.15	$ 5.00
Coal per ton	$77 - 94	$120

		Annual Costs		Capital Costs
		Scenario		excl. mine
		A	III	
		$1,000	$1,000	$1,000
8.05.3.1	Base line case	2,192	4,890	500
8.05.3.2	Interim prov. of coal to homes	635	1,022	834
8.05.3.3	A-II	1,387	1,892	7,342
8.05.3.4	A-II-A with Ormat	1,737	2,229	10,356
8.05.3.5	A-II-A with Rotoflow	1,692	2,059	11,211
8.05.3.6	A-II-A with Mafi-Trench	1,746	2,164	11,051
8.05.3.7	A-1	1,845	2,260	10,480
8.05.3.8	A-2	1,969	2,653	9,241

These annual costs will be discussed in the following section 9.0.

8.05.3.1. Annual Cost
Base-line case

Capital cost of existing diesel generating plant (assumed)	$ 500,000
Total capital costs	$ 500,000

Annual Costs

Scenario	A	III
Diesel fuel oil per gallon	$ 2.15	$ 5.00
Fixed Costs	$ Per Annum	
Interest on bonds (8% on ½ capital costs)	20,000	20,000
Retirement of capital (25 years - 4% p.a.)	20,000	20,000
Operating Costs		
Labor	160,000	240,000
Fuel oil 915,000 gal.	1,967,250	4,575,000
Maintenance, spares etc.	25,000	35,000
Total annual costs	2,192,250	4,890,000

8.05.3.2 Annual Costs
Interim provision of coal to home owners

Capital cost of existing diesel generating plant (assumed)	$ 500,000
Capital cost of house installations assumed @ $2000 per house pending completion of task 6, 167 houses	334,000
Total capital costs	$ 834,000

Annual Costs

Scenario	A	III
Diesel fuel oil per gallon	$ 2.15	$ 5.00
Coal per ton (production 2,200 tons p.a)	$ 100	$ 120
Fixed Costs		
Interest on bonds (8% on ½ capital costs)	33,360	33,360
Retirement of capital (25 years - 4% p.a.)	33,360	33,360
Operating Costs		
Labor	80,000	100,000
Coal 2200 tons	220,000	264,000
Fuel oil 106,250 gal.	228,440	531,250
Maintenance, spares etc.	40,000	60,000
Total amount cost	635,160	1,021,970

8.05.3.3 Annual Costs
Alternative A-II

Capital cost of plant and distribution system	$ 5,979,010
Capital cost of house installations	863,000
Capital cost of existing diesel generating plant (assumed)	$ 500,000
Total capital requirement	$ 7,342,010

Annual Costs

Scenario	A		III
Diesel fuel oil per gallon	$ 2.15		$ 5.00
Coal per ton (annual prod. 4,000 tons)	$ 94		$ 120.00
Fixed Costs		$ Per Annum	
Interest on bonds (8% on ½ capital costs)	293,680		293,680
Retirement of capital (25 years - 4% p.a.)	293,680		293,680
Operating Costs			
Labor	160,000		240,000
Coal 3947 tons	371,000		473,640
Oil fuel 106,250 gal.	228,450		531,250
Maintenance, spares etc.	40,000		60,000
Total annual costs	1,386,810		1,892,250

8.05.3.4 Annual Costs
Alternative A-II-A with Ormat

Capital cost of plant and distribution system	$ 8,992,810
Capital cost of home installations	$ 863,000
Capital cost of existing diesel generating plant (assumed)	500,000
Total capital requirement	$10,335,810

Annual Costs

Scenario	A		III
Diesel fuel oil per gallon	$ 2.15		$ 5.00
Coal per ton (annual prod. 8,757 tons)	$ 77.00		$120.00
Fixed Costs		$ Per Annum	
Interest on bonds (8% on ½ capital costs)	414,230		414,230
Retirement of capital (25 years - 4% p.a.)	414,230		414,230
Operating Costs			
Labor	160,000		240,000
Coal 8,757 tons	674,290		1,050,840
Oil fuel (standby) 2,000 g.	4,300		10,000
Maintenance, spares etc.	70,000		100,000
Total annual costs	1,737,050		2,229,300

8.05.3.5 Annual Costs
Alternative A-II-A with Rotoflow

Capital cost of plant and distribution system	$ 9,848,210
Capital cost of house installations	$ 863,000
Capital cost of existing diesel generating plant (assumed)	$ 500,000
Total capital requirement	$ 11,211,210

Annual Costs

Scenario	A		III
Diesel fuel oil per gallon	$2.15		$ 5.00
Coal per ton (annual prod. 6.722)	$84.00		$120.00
Fixed Costs		$ Per Annum	
Interest on bonds (8% on ½ capital costs)	448,450		448,450
Retirement of capital (25 years - 4% p.a.)	448,450		448,450
Operating Costs			
Labor	160,000		240,000
Coal 6,722 tons	564,648		806,640
Oil fuel (standby) 5,000 g	10,750		25,000
Maintenance, spares etc.	60,000		90,000
Total annual costs	1,692,298		2,058,540

Note: due to lower capacity and efficiency when temperatures and exceed -45F above figures for operating costs are undertated.

8.05.3.6 Annual Costs Alternative A-II-A with Mafi-Trench

Capital cost of plant and distribution system	$ 9,687,760
Capital cost of house installations	$ 863,000
Capital cost of existing diesel generating plant (assumed)	$ 500,000
Total capital requirement	$11,050,760

Annual Costs

Scenario	A		III
Diesel fuel oil per gallon	$ 2.15		$ 5.00
Coal per ton (annual prod. 7.747)	$ 81.00		$120.00
Fixed Costs		$ Per Annum	
Interest on bonds (8% on ½ capital costs)	442,030		442,030
Retirement of capital (25 years - 4% p.a.)	442,030		442,030
Operating Costs			
Labor	160,000		240,000
Coal 7,747 tons	627,500		929,640
Oil fuel (standby) 2,000 g	4,300		10,000
Maintenance, spares etc.	70,000		100,000
Total annual costs	1,745,860		2,163,700

8.05.3.7 Annual Costs Alternative A-1

Capital cost of plant and distribution system	$ 8,916,710
Capital cost of house installations	$ 863,000
Labor training program	$ 699,750
Total capital requirement	$10,479,460

Annual Costs

Scenario	A	III
Diesel fuel oil per gallon	$ 2.15	$ 5.00
Coal per ton (annual prod. 5850 tons)	$ 90.00	$120.00
Fixed Costs	$ Per Annum	
Interest on bonds (8% on ½ capital costs)	419,180	419,180
Retirement of capital (25 years - 4% p.a.)	419,180	419,180
Operating Costs		
Labor	400,400	600,000
Coal 5850 tons	526,500	702,000
Maintenance, spares etc.	80,000	120,000
Total annual costs	1,845,260	2,260,360

8.05.3.8 Annual Costs Alternative A-2

Capital cost of plant and distribution system	$ 8,304,480
Capital cost of house installations	$ 237,375
Labor training program	$ 699,750
Total capital requirement	$ 9,241,605

Annual Costs

Scenario	A		III
Diesel fuel oil per gallon	$ 2.15		$ 5.00
Coal per ton (annual prod. 9,450 tons)	$75.00		$120.00
Fixed Costs		$ Per Annum	
Interest on bonds (8% on ½ capital costs)	369,664		369,664
Retirement of capital (25 years - 4% p.a.)	369,664		369,664
Operating Costs			
Labor	400,400		600,000
Coal 9,450 tons	708,750		1,134,000
Maintenance, spares etc.	120,000		180,000
Total annual costs	1,968,478		2,653,328

9.0 INTERIM MEASURES

9.01 General

At an early stage in the initial study it was recognized, that there may be a desire to implement early interim measures to reduce as quickly as possible the cost of domestic space heating without waiting for possible long term central district heating plans to mature.

Task 6 in the current study provides for investigating the cost and benefits of dual fuel furnaces or stoves for home heating.

In Section 12 dealing with a conceptual plan for the recommended system, a phasing plan is described which would accommodate the earliest possible development of the mine, based on the coal extraction at the rate of 20 tons per family per annum. Such permits could be obtained without having to wait for a congressional waiver as would be the case for the "commercial" use of coal, reference page 5-6, Volume 1.

As will be apparent from Section 10.0 following, there is at this time no conclusion as to what the views of the village people are on the question on interim use of coal for direct firing in the homes.

If the hurdle of a congressional waiver is passed reasonably expeditiously, as now appears might be the case, indications are, that few people would want to go to the expense of installing equipment for the interim use of coal only to see it obsolete within 1 or 2 years.

9.02 Interim House Installations

Numerous manufacturers, many of whom offer a variety of models, sizes and features, are in the market of multi-fuel and add-on furnaces today. However, only a limited number of these can be expected to be suitably supplied and serviced in Alaska due to the area's remoteness and the market's limited size. By a survey, which does not claim to be complete, the following makes were found to be available in Alaska and the suppliers reasonably believed to have the necessary service capability:

a. PRILL's, distributed by PMC Corporation, Sheridan, WY.

b. CWO-B and CWF, distributed by Duomatic/Olsen, Inc., Park Forest South, IL.

c. YUKON, distributed by Yukon Industries, Minneapolis, MN.

d. BUDERUS, distributed by Envirotherm, Bingham, NY.

e. HS-TARM, distributed by Tekton Corporation, Conway, MA.

f. Various stoves.

The houses in Wainwright may very roughly be divided into three main groups, which each requires a different type of stove or furnace:

1. Old and small houses, primarily with one room only, which will require the installation of a centrally placed coal stove.

2. Houses with more rooms heated by means of an oil burner and a forced-air system. These will require the installation of an add-on coal furnace or a multi fuel furnace, designed to serve a forced-air distribution system.

3. Houses with more rooms heated by means of an oil burner and a water/glycol system. These will require installation of an add-on coal furnace or a multifuel furnace, designed for the water/glycol distribution system.

It can be set as a main guideline, that new houses be equipped with multifuel furnaces and that existing houses with oil burners in good conditions be equipped with add-on coal furnaces.

Following is a very short description with advantages and disadvantages of the different makes. Prices and cost estimates are given in round figures and are approximate.

Make: PRILLS'

Description: Hopper or bin feed self-cleaning coal furnaces.

Range: 100,000 BTU/h and 200,000 BTU/h (based on 10,000 BTU/lb coal), i.e. output 10-15% less for Wainwright.

Fuel: Coal and biomass.

Distribution System: Forced air.

Advantages: Uses sub-bituminous coal, liqnite and bio-mass.

Disadvantages: Large space requirement. Mechanical parts in feeders susceptible to wear and breakdown. Feeder stop will shut down the furnace.

Prices:

Retail, Anchorage	$2,600-2,9
Freight, Anchorage-Wainwright	$ 500- 700
Installation	$1,500-2,5
Total	$4,600-6,1

PRILL

SOLID FUEL HEATING

PHONE 307—672-5801
DRAWER S SHERIDAN, WYOMING 82801

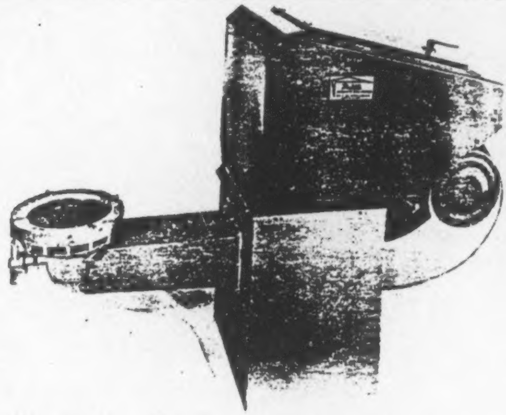
STOKER FIRING

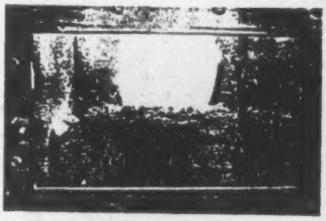
BIO MASS FUEL *or* STOKER COAL

MODELS 100 and 200

HOPPER STOKERS

RING 'O' FIRE

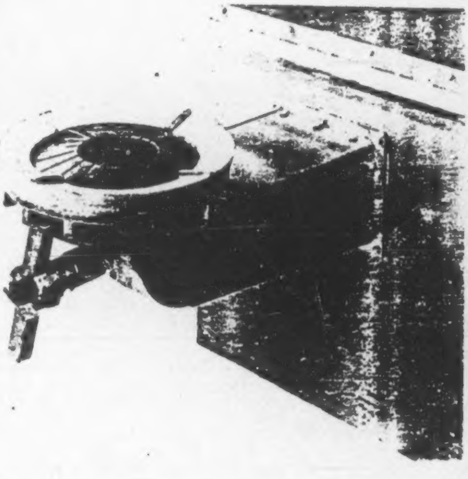




NO CLINKERS

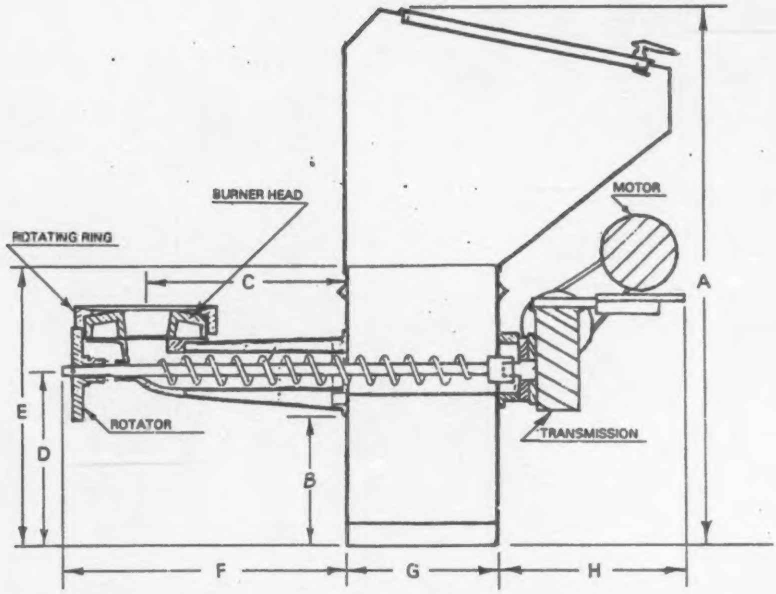
PMC burner head with rotating ring is the heart of the unit. The design controls combustion for more even heat production. Ash falls evenly off the outer edge of the ring, eliminating clinker build-up, as fresh fuel is pushed up through the center of the head.

- PRILL'S UNIQUE BURNER HEAD DESIGN ALLOWS EVEN, CONTROLLED COMBUSTION. NO FIRE BRICK REQUIRED.
- NO MORE MESSY CLINKER REMOVAL—PRILL'S BURNER HEAD DESIGN AND ROTATING RING PREVENTS CLINKER FORMATION.
- LIGHT ONCE AND FORGET IT—HOLD FIRE TIMER ASSURES A LIVE BED OF COALS AND INSTANT HEAT WHEN NEEDED.
- ENJOY THE WARMTH AND COMFORT OF COAL HEAT OR BIO MASS FUEL.*
- COAL & BIO MASS FUEL IS THE ONLY ECONOMICAL FUEL AVAILABLE—SAVE AS MUCH AS 50% OVER OTHER FUELS.
- AUTOMATIC HEAT IN A SINGLE PACKAGE.



* Bio Mass Fuel — All vegetative material in pellet form.

NOTE: FOR USE WITH SUB-BITUMINOUS, LIGNITE COAL AND BIO MASS FUEL.



	A	B	C	D	E	F	G	H
MODEL 100	43½	10½	16	14¾"	22½	22	12	16½
MODEL 200 ·	44	10½	20	14¾"	22½	26½	16	17½
MODEL 200 - Long Nose -*			38			44½		

* Dimensions C and F will vary with nosing length.

MODELS	100H	200H
Minimum Fire Box Diameter	18"	20"
Size	12"	14"
Stoker Motor H.P.	¼	¼
Flue Size	6	8
*Lbs. Coal Fed Per Hour-Max.	16	30
Hopper Capacity	280-Lb. Coal – 212-Lb. BM	340-Lb. Coal – 258-Lb. BM
Type Vent Required	All Fuel	All Fuel
Recommended Height of Chimney Above Roof Peak	30"	30"
Approximate Shipping Wt.	260 lbs.	321 lbs.

(Specifications subject to change without notice)
No Electronic Control Panel Included (Stoker Relay Timer)

Voltage-110V

* Coal Feed Varies With Different Types of Stoker Coal or Bio Mass Fuel.

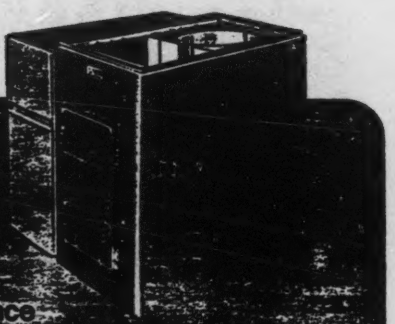
Make:	CWO-B	
Description:	Automatic multi-fuel furnace.	
Range:	112,000 - 151,000 BTU/h, when operated on oil	
Fuel:	Coal, wood and gas or oil.	
Distribution System:	Forced air.	
Advantages:	Dual combustion chambers with dual thermostatic controls.	
Disadvantages:	Complete system, i.e. for new construction, primarily. No built-in hot water capacity	
Prices:	Retail, Anchorage	$2,800
	Freight, Anchorage-Wainwright	$ 700
	Installation	$1,500-2,500
	Total	$5,000-6,000

Make:	CWF	
Description:	Automatic solid-fuel add-on furnace	
Range:	120,000 BTU.	
Fuel:	Coal and wood.	
Distribution System:	Forced air.	
Advantages:	Add-on to existing forced-air furnace. Thermostatic control.	
Disadvantages:	No built-in hot water supply.	
Prices:	Retail, Anchorage:	$1,300
	Freight, Anchorage-Wainwright	$ 400
	Installation	$1,500-2,5
	Total	$3,600-4,2

DUO-MATIC

CWO·B

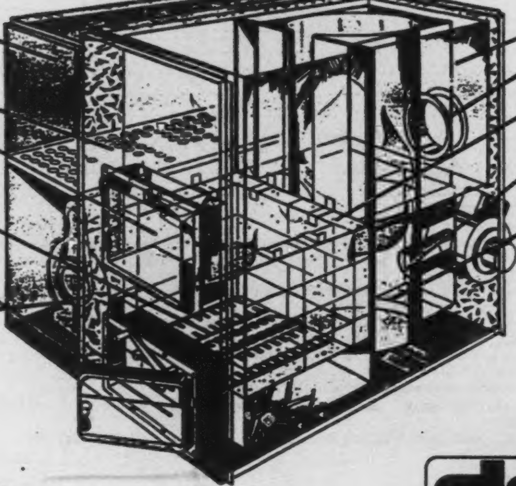
multi-fuel furnace



The 2-in-1 automatic home heating system that combines the convenience of oil or gas and the economy of wood and coal in a single unit.

This side burns wood & coal

This side burns gas or oil


Blower Section assembles on Right or Left Hand Side of Heat Exchanger.
Regular size spun glass Disposable Filters.
One piece air tight Doors.
Cast Iron Grates—Heavy duty Cast Iron Grates can be used for wood or coal burning application. Shaker handle included.
Ash Pit Door—Easy access to convenient removable ash pan.
High capacity Twin Blower.
Heavy Duty welded construction.
7" diameter Flue Pipe
Fire Brick—Solid fuel side lined with 2½" thick heavy duty Fire Brick rated for up to 3000°F.
Flame Retention Head Oil Burner with burner mounted oil safety relay.
Fiber Ceramic Chamber in regular fuel section for greater efficiency.

Quality built to last.
Certified by C.S.A.

CWO·B —The combination coal-wood-gas & oil forced air furnace which can pay for itself.

Features:
• Dual combustion chambers • Dual thermostatic controls • Quiet, dependable operation • Your choice of fuels • Money SAVINGS!

DUO-MATIC

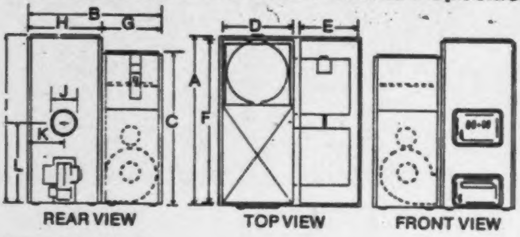
MULTI -FUEL FURNACES

The Largest Selling Multi-Fuel Furnace in North America.

DUO-MATIC CWO•B SERIES

Burns wood and coal, gas or oil.

Dimensions CWO-B SERIES Furnace Specifications



A =Depth 48¼"
B =Width 44⅛"
C =Blower Section Height 45½"
D+F=Hot Air Plenum 24 x 46⅛"
E+F=Cold Air Plenum 16⅛ x 46⅛"
G =Blower Section Width 18⅛"
H =Furnace Section Width 26"
I =Furnace Section Height 51¼"
J =Flue Pipe Dia. 7"
K =Flue Pipe to Centre Furnace Section 13"
L =Flue Pipe to Centre From Floor 35⅝"

Specifications

MODEL	CWO-B 112				CWO-B 140					
BTU Bonnet	112,000		123,000		134,000		140,000		151,000	
Nozzle	1.00 - 80		1.10 - 80		1.20 - 70		1.25 - 70		1.35 - 70	
Comb. Chamber	2FA		2FA		2FA		2FA		2FA	
Air Filters	2 - 16 x 24		2 - 16 x 24		2 - 16 x 24		2 - 16 x 24		2 - 16 x 24	
Ex. Static	.20		.20		.20		.20		.20	
Blower CFM	1,200		1,320		1,440		1,500		1,625	
Blower Make	DELHI	LAU	DELHI	LAU	DELHI	LAU	DELHI	LAU	DELHI	LAU
Motor Pulley	3¼	3½	3¼	3½	3¼	3½	3¼	3½	3¼	3½
Turns Open	2	2	0	0	1	1	½	½	0	0
Blower Pulley	9	9	9	9	8	8	8	8	8	8
Motor H.P.	¼	¼	¼	¼	⅓	⅓	⅓	⅓	⅓	⅓
Blower Size	G9-2 twin	2A9-9AC twin	G9-2 twin	2A9-9AC twin	G9-2 twin	2A9-9AC twin	G9-2 twin	2A9-9AC twin	G9-2 twin	2A9-9AC twin
Shipping Weight	970		970		970		970		970	

SHIPPING INFORMATION:
Your furnace is packed in 7 pieces.

1. Furnace heat exchanger, complete with fire and ash pit doors, ash pan, grate bars, burner mounting plate, fibre oil combustion chamber, panels including heat exchanger spacer panel, pokers, brick guard, brick shims and brick retainers.

2. Blower section (can be mounted left or right hand) complete with blower, miscellaneous parts bag, filters and centre panel for heat exchanger section.

3. (a) Burner with flame retention head and oil combustion safety control. (b) Field wiring junction box with transformer, solid fuel relay, blower wiring harness, burner cable and fan limit control with support. (c) Belt and pulleys. (d) Solid fuel damper motor. (e) Thermostats for solid fuel and oil. (f) Smoke baffle tool. (g) Blower motor. (h) Draft regulator. (i) Shaker handle.

4, 5 and 6. Three cartons containing a total of 30 firebricks.

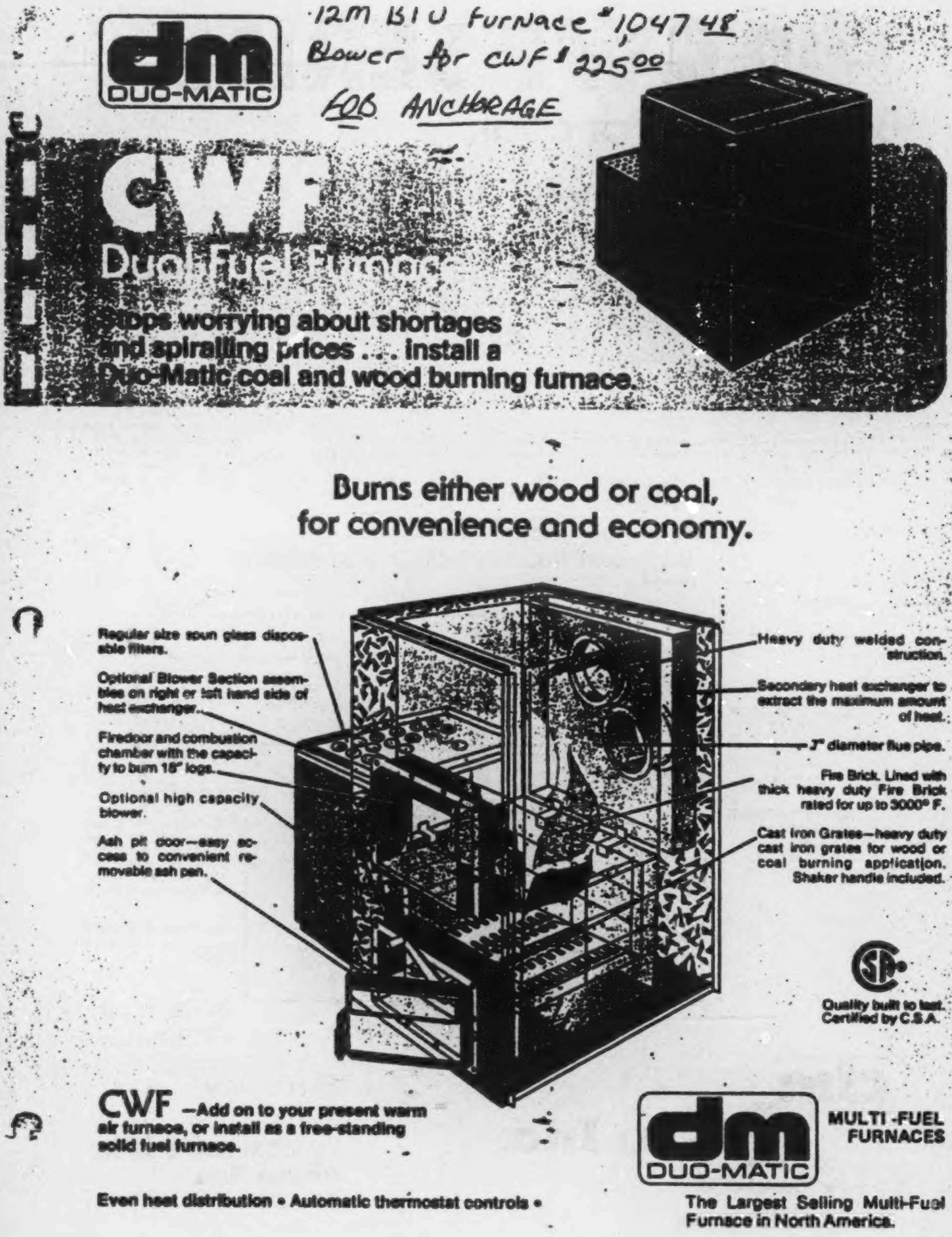
*U.S. shipments are made up of 7 pieces. The burner with primary relay, blower motor, belt and pulleys are packed in a separate carton.

SPECIFICATIONS AND DIMENSIONS SUBJECT TO CHANGE WITHOUT NOTICE.

DUO-MATIC Olsen Inc.

Duo-Matic/Olsen, Inc.
2510 Bond Street
Park Forest South, IL 60466

CWO-B78



12M BTU Furnace $1,047 48
Blower for CWF $225 00
FOB ANCHORAGE

DUO-MATIC

CWF
Dual Fuel Furnace

Stops worrying about shortages and spiralling prices . . . . install a Duo-Matic coal and wood burning furnace.

Burns either wood or coal, for convenience and economy.

Regular size spun glass disposable filters.

Optional Blower Section assembles on right or left hand side of heat exchanger.

Firedoor and combustion chamber with the capacity to burn 18" logs.

Optional high capacity blower.

Ash pit door—easy access to convenient removable ash pan.

Heavy duty welded construction.

Secondary heat exchanger to extract the maximum amount of heat.

7" diameter flue pipe.

Fire Brick. Lined with thick heavy duty Fire Brick rated for up to 3000° F.

Cast Iron Grates—heavy duty cast iron grates for wood or coal burning application. Shaker handle included.

Quality built to last. Certified by C.S.A.

CWF —Add on to your present warm air furnace, or install as a free-standing solid fuel furnace.

Even heat distribution • Automatic thermostat controls •

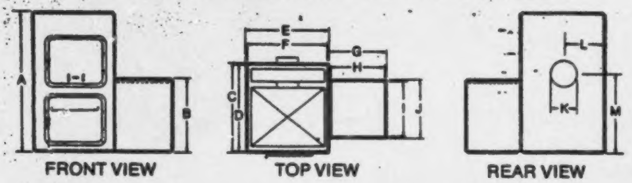
DUO-MATIC MULTI-FUEL FURNACES

The Largest Selling Multi-Fuel Furnace in North America.

DUO-MATIC CWF SERIES

Burns wood or coal.

Specifications and Dimensions for CWF Furnace



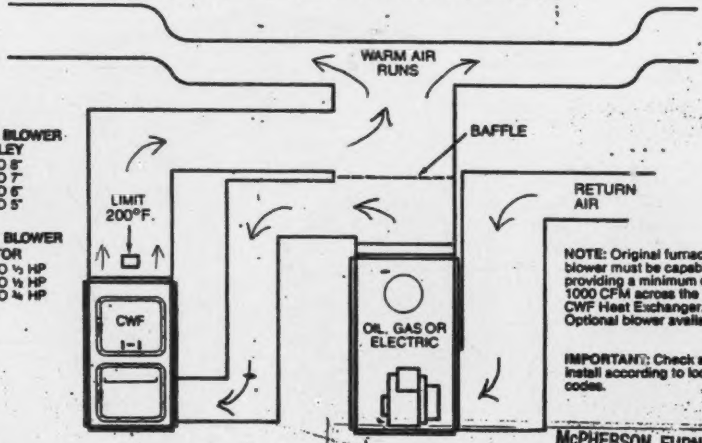
Dimensions:

A=Furnace section height 52¾".
B=Blower section height 30¾".
C=Furnace section depth 33¾".
D x F=Hot air plenum 24¾"w x 31¾"l.
E=Furnace section width 27¾".
G=Blower section width 21¾".
H x I=Cold air plenum 19¾"w x 18¾"l.
J=Blower section depth 20"
K=Flue pipe dia. 7".
L=Flue pipe to center furnace section 13¾".
M=Flue pipe to center from floor 34½".

Specifications:

- Solid fuel combustion chamber: Fire brick lined with cast iron grates. Size: 18" × 17" × 14"
- Firing Door: 16¾" × 13½".
- Insulated Cabinet: Foil faced mineral fibers.
- Flue outlet: 7" • Blower motor: ⅓ HP.
- Blower: CFM-1000 • Blower: 9" wheel type.
- Ex. Static: 20 • Air filter: 1 20" x 20".
- B.T.U.: Estimated max. 120,000.
- Shipping weight: Complete 625 lbs.

Suggested Wood ADD-ON Duct Installation



CONVERT BLOWER PULLEY
9" TO 8"
8" TO 7"
7" TO 6"
6" TO 5"

CONVERT BLOWER MOTOR
¼ HP TO ⅓ HP
⅓ HP TO ½ HP
½ HP TO ¾ HP

NOTE: Original furnace blower must be capable of providing a minimum of 1000 CFM across the CWF Heat Exchanger. Optional blower available.

IMPORTANT: Check and install according to local codes.

McPHERSON FURN. & EQ. C
6721 Arctic Spur Rd.
Anchorage, AK 99502

AVAILABLE FROM

McPHERSON FURN. & EQ. CO.
Anchorage, Alaska
(907) 274-7251

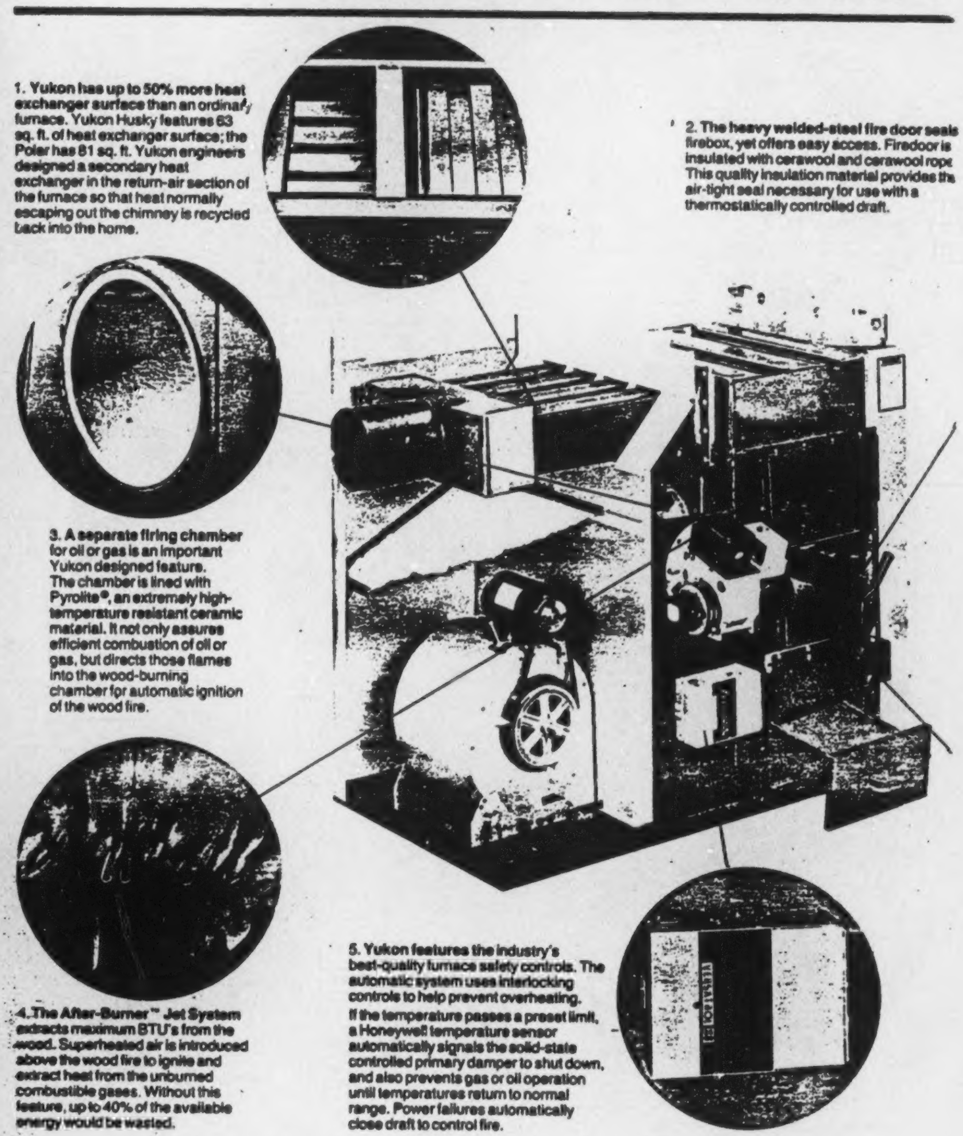
DUO-MATIC Olsen Inc.

Duo-Matic/Olsen, Inc.
2510 Bond Street
Park Forest South, IL 60466

Make:	YUKON HUSKY and YUKON POLAR.	
Description:	Automatic multi-fuel furnace.	
Range:	85,000 BTU/h - 168,000 BTU/h, when operated on oil.	
Fuel:	Coal, wood and gas or oil.	
Distribution System:	Forced air.	
Advantages:	Dual combustion chambers and safety devices to protect against overheating.	
Disadvantages:	Complete system, i.e. for new construction primarily. No built-in hot water capacity.	
Prices:	Retail, Anchorage:	$2,500-2,800
	Freight, Anchorage-Wainwright	$ 500- 700
	Installation	$1,500-2,500
	Total	$4,500-6,000

Make:	BUDERUS LOGANA 02.40.	
Description:	Solid fuel boiler	
Range:	108,000 BTU/h - 160,000 BTU/h based on coal operation	
Fuel:	Coal and wood. Can be converted to burn oil or gas.	
Distribution System:	Hot water/glycol	
Advantages:	May act as an add-on. Convertible to gas or oil. Able to provide hot water as well.	
Disadvantages:	One combustion chamber when operated as a dual fuel furnace.	
Prices:	Retail, Anchorage:	$2,000-2,600
	Freight, Anchorage-Wainwright	$ 400- 600
	Installation	$1,500-2,500
	Total	$3,900-5,700

Each Yukon Furnace is a



1. Yukon has up to 50% more heat exchanger surface than an ordinary furnace. Yukon Husky features 63 sq. ft. of heat exchanger surface; the Polar has 81 sq. ft. Yukon engineers designed a secondary heat exchanger in the return-air section of the furnace so that heat normally escaping out the chimney is recycled back into the home.

2. The heavy welded-steel fire door seals firebox, yet offers easy access. Firedoor is insulated with cerawool and cerawool rope This quality insulation material provides the air-tight seal necessary for use with a thermostatically controlled draft.

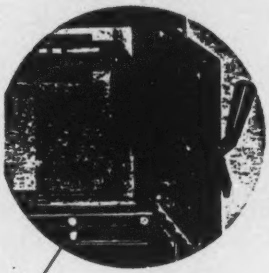
3. A separate firing chamber for oil or gas is an important Yukon designed feature. The chamber is lined with Pyrolite®, an extremely high-temperature resistant ceramic material. It not only assures efficient combustion of oil or gas, but directs those flames into the wood-burning chamber for automatic ignition of the wood fire.

4. The After-Burner™ Jet System extracts maximum BTU's from the wood. Superheated air is introduced above the wood fire to ignite and extract heat from the unburned combustible gases. Without this feature, up to 40% of the available energy would be wasted.

5. Yukon features the industry's best-quality furnace safety controls. The automatic system uses interlocking controls to help prevent overheating.

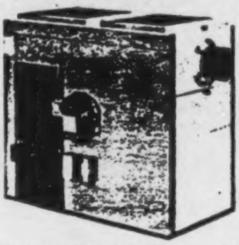
If the temperature passes a preset limit, a Honeywell temperature sensor automatically signals the solid-state controlled primary damper to shut down, and also prevents gas or oil operation until temperatures return to normal range. Power failures automatically close draft to control fire.

totally engineered system

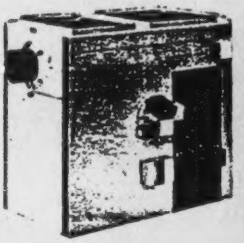


LWO-112
HUSKY
Wood/Coal/Oil

KLONDIKE
Wood/Coal

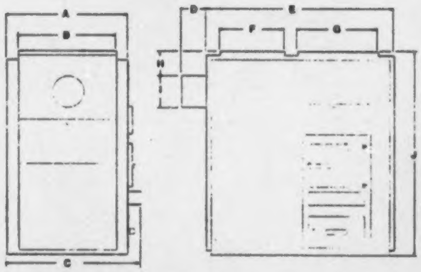


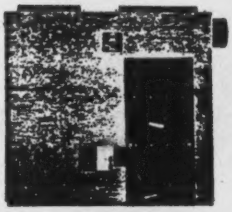
The Yukon Husky is a combination fuel furnace that can comfortably heat properly insulated homes up to 3,000 sq. ft. Available in wood/coal/oil and wood/coal/gas.



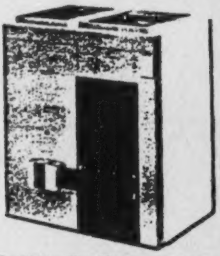
The Yukon Polar is Yukon's largest capacity furnace which can comfortably heat properly insulated homes up to 4,000 sq. ft. It features 22% more heat exchanger surface than the Husky. Available in wood/coal/oil and wood/coal/gas.

DIMENSIONS





The Yukon Wood/Electric is a 20 KW four-stage combination furnace which offers both the convenience of electricity and the economy of wood. Depending on geographic location and proper insulation, this furnace can comfortably heat homes up to 1,500 sq. ft.



The Yukon Klondike operates alone as an efficient woodburning furnace or can be used as an add-on in conjunction with an existing oil, gas or electric furnace. The Klondike can comfortably heat properly insulated homes up to 3,000 sq. ft.

MODEL	A	B	C	D	E	F	G	H	I	J
HUSKY	30"	24"	33½"	6"	56"	20"	24"	6"	8"	50¾"
POLAR	30"	24"	33½"	5"	60"	20"	24"	11"	8"	61⅞"
WOOD/ELEC	30"	24"	32½"	5½"	53"	16"	20"	2¾"	8"	50¾"
KLONDIKE	30"	24"	33½"	6"	46"	16"	20"	6"	8"	50¾"

6. The optional cast iron "shaker" grate for coal is extra rugged to resist warping or sagging. The Yukon grate lasts far longer than ordinary rod/steel or welded-type grates.

SPECIFICATIONS

MODEL	HUSKY LWO 85	HUSKY LWO 100	HUSKY LWO 112	POLAR LWO 151	POLAR LWO 168	WOOD ELECTRIC	KLONDIKE
BTU Input	106,000	125,000	140,000	189,000	210,000	68,260 20 KW	175,000 Max.
Fuel	Available in Wood/oil or Wood/gas			Wood/oil or Wood/gas		Wood/Electric	Wood
BTU Output	85,000	100,000	112,000	151,000	168,000	68,260	131,000 Max.
Nozzle	75 (80H)	90 (80H)	1.00 (80H)	1.35 GPH	1.5 GPH	N/A	N/A
Blower Size	10" x 10"	10" x 10"	10" x 10"	12" x 12"	12" x 12"	10" x 10"	10" x 10"
Motor Size	1/3 HP	1/3 HP	1/3 HP	1/3 HP	1/3 HP	1/3 HP	1/3 HP
Blower CFM	800-1400	800-1400	800-1400	1200-1800	1200-1800	800-1400	800-1400
Lining	Firebrick	Firebrick	Firebrick	Firebrick	Firebrick	Firebrick	Firebrick
Grates	Cast iron	Cast iron	Cast iron	Cast iron	Cast iron	Cast iron	Cast iron
Wood Chamber	24" x 16"	24" x 16"	24" x 16"	24" x 18"	24" x 18"	24" x 16"	24" x 16"
Fire Door	10" x 10"	10" x 10"	10" x 10"	13¼"x13¼"	13¼"x13¼"	10" x 10"	10" x 10"
Air Filter	20x25x1	20x25x1	20x25x1	20x25x1	20x25x1	Field-Installed in Plenum	20x25x1
Cabinet	Insulated	Insulated	Insulated	Insulated	Insulated	Insulated	Insulated
Chimney Flue	Available left or right outlet						
Shipping Weight	869 lbs.			1,072 lbs.		875 lbs.	720 lbs.
Heat Exchanger	63 sq. ft.			81 sq. ft.		58 sq. ft.	53 sq. ft.
Secondary Air System	yes	yes	yes	yes	yes	yes	yes

Specifications subject to change without notice.

Buderus

»Logana« 02.40
solid fuel boiler, convertible to oil and gas

Boiler block

The Buderus »Logana« 02.40 is a cast iron sectional boiler. It is specially suitable for solid fuel firing. Conversion to oil or gas firing is possible.

The wet base guarantees an even combustion without slag formation and allows good controlability.

The boiler sections are hydrostatically tested in the factory at 2½ times working pressure, the assembled section blocks at 1½ times working pressure.

From the combustion chamber the hot gases pass to the flue gas channels.

The ample dimensions of these channels largely prevent soot and fly-ash deposits and facilitate cleaning. The draft requirement is particularly small.

The loading door opening is generously dimensioned.

A particularly large ash box is suited to the larger volume of ash from wood firing.

Cleaning is done from the front, the flue gas channels being accessible from the loading, and the combustion chamber from the ash door. Practical handles on ash and loading door facilitate operation.

Under the blue boiler jacket the complete boiler is covered with a high efficiency heat insulation. The individual parts of the boiler jacket are easy to assemble.

Fuel

Wood and coal.
Convertible to light oil or gas firing.

Adaptation for oil or gas firing

The heating boiler can be adapted with conversion parts to oil and gas firing.

The ash door is replaced by a burner door, the burner hole can be drilled up to a maximum of 44 in. dia.

Water connections

Item	Normal size	Connection
KV	2"	Boiler flow
KR	2"	Boiler return
SV	1¼"	Safety flow
SR	1"	Safety return
EK	–	Boiler drain, fitted at the jobsite
F	¾"	Firing controller
–	½"	Tapping for thermometer
–	¾"	Tapping for temperatur control of oil/gas firing

Oil and gas burner

The burner flame must suit the dimensions of the combustion chamber.

The burner head equipment specified by the manufacturer must be used. For burner type and size consult your dealer.

Control

For solid fuel firing the boiler is controlled by a firing controller.

For oil and gas firing a limit control and a thermometer are fitted at the jobsite.

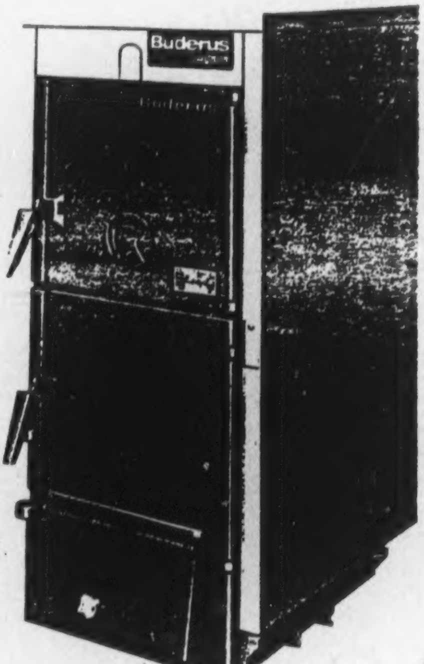
Chimney connection

The chimney should be dimensioned to suit the boiler rating and draft requirements taking into consideration the site conditions and the appropriate technical rules.

Particular attention should also be given to the variation of flue-gas volumes when different fuels are used.

Operating characteristics

Hot water up to 230°F and 58 psi pressure.



A.S.M.E. Approved

Short description of boiler

(Standard equipment)

Sectional cast iron heating boiler with wet base. Flue box with damper and damper positioner, loading door, ash door with damper, deep ash pan, threaded flanges for boiler flow and return, cleaning brushes, firing controller, operating and assembly instructions. Blue boiler jacket and heat insulation. Installation package, pressure relief valve, over heat control, boiler thermometer, warranty.

Delivery and packing

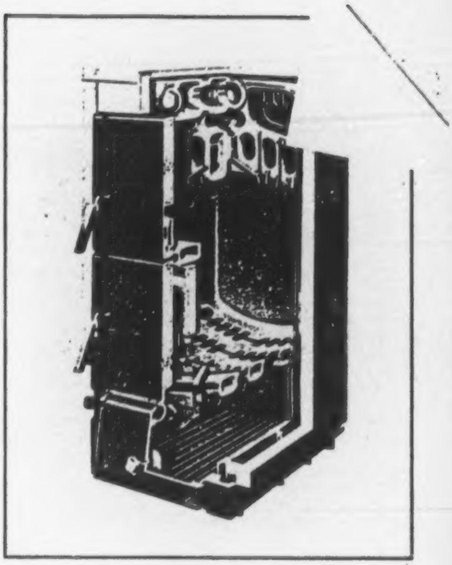
1 Skid:
Boiler block with doors. Flue box, ash pan, cleaning brushes, firing controller, joints, assembly and operating instructions (packed in combustion chamber).

1 Cardboard box:
Boiler jacket with insulation and brush handle.

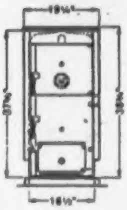
1 Cardboard box:
Installation package, pressure relief valve, over heat control, boiler thermometer, warranty.

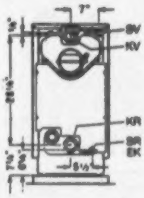
Optional equipment (when ordered) separately packed:

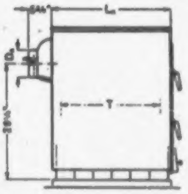
- Fuel conversion parts for oil or gas firing (size to be stipulated).
- Rake and poker (solid fuel).

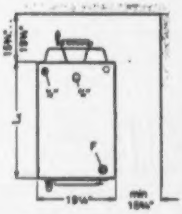


»Logana« 02.40









Boiler size	Boiler length L_K in.	Combustion chamber length T in.	Fuel volume approx. US gal.	Water contents approx. US gal.	Chimney Draft requirements Solid fuel in WC	Chimney Draft requirements Oil/Gas in. WC	Flue connection dia. D_A in.	Net weight approx. lbs.	Net ratings with coal, oil gas BTU/Hr.	Net ratings with hardwood BTU/Hr.
27	23	19⅛	20	8⅝	0,040	0,036	7	680	108.000	96.000
35	27	23⅛	25	10	0,048	0,040	7	708	140.000	125.000
40	34⅛	31⅛	33	12⅛	0,052	0,048	7	876	160.000	145.000

*) Hardwood, such as birch, oak, maple, etc. With pine, spruce and similar woods reduced ratings.

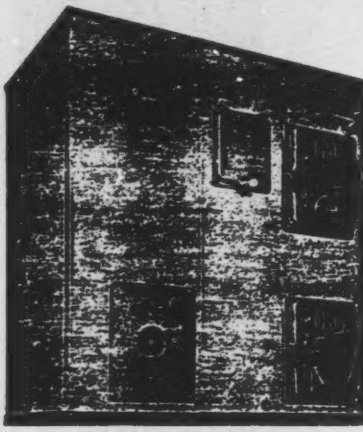
Larger styles available up to 300,000 BTU.

envirotherm, inc. Box 428 • Binghamton • New York 13902

Make:	HS-TARM TYPE OT
Description:	Automatic multi-fuel furnace.
Range:	112,000 BTU/h - 280,000 BTU/h when operated on oil.
Fuel:	Coal, wood, electricity and gas or oil.
Distribution System:	Hot water/glycol.
Advantages:	Dual combustion chambers and automatic protection against overheating. Built-in hot water supply.
Disadvantages:	Complete system, i.e. for new construction primarily.

Make:	HS-TARM TYPE MB-SOLO
Description:	Solid fuel boiler.
Range:	72,000 BTU/h - 180,000 BTU/h when operated on wood.
Fuel:	Coal and wood. Can be converted to operate on oil or gas.
Distribution System:	Hot water/glycol.
Advantages:	May act as an add-on. Convertible to gas or oil Built-in hot water supply.
Disadvantages:	One combustion chamber, when operated as a dual-fuel furnace.

HS•TARM TYPE OT Multi-Fuel Boiler



General Information

The HS Tarm Type OT is a new energy-conserving steel plate boiler for modern residential hydronic heating and domestic hot water supply. The Type OT boiler is manufactured in Denmark, a country known throughout the world for its excellent heating products. Designed primarily for efficiency and flexibility, the Type OT provides heat and hot water year 'round from a variety of fuels. Wood can be used in combination with oil, gas, or electricity. On the left side of the Type OT is the combustion chamber for oil or gas, and on the right, a large firebox for wood. The three center tappings are for the optional installation of electrical heating elements. An automatic draft regulator controls the wood fire. Should the wood fire die down or be allowed to go out, the control system automatically switches on the back-up unit — oil, gas, or electric — to maintain boiler temperature. In addition, the Type OT can be supplied with shaker grates for burning coal or coke.

Combustion

The large firebox employs a base-burning arrangement to maximize efficiency. As wood is heated in any fire, it emits gases, which, when burned, yield heat. When they are not burned they can represent a significant loss of efficiency. In a boiler they can also causes tar-like deposits commonly called creosote. These deposits are formed by the condensation of some flue gases when they are cooled. The Type OT's base-burning principle encourages burning of these gases. Much of the smoke leaves the firebox at its base, where flammable gases are drawn over the fire's hot coals. Additional air for this combustion is provided by the secondary air inlet in the upper door of the firebox. Due to the fact that the wood firebox is surrounded by water, the firebox walls are maintained at a relatively cool (200°F.) temperature. The low temperature of these walls precludes the use of wood at a moisture content of greater than 20%. Use of such "green" wood will result in poor burning and excessive formation of creosote and soot. Well-seasoned wood is required for proper boiler operation. A flap-like damper ("A" in the cross section drawings) controls the relative amount of smoke leaving the top and bottom of the firebox. The damper is operated through the cleaning door in the center of the boiler.

When the damper is in the vertical position, much of the smoke will be drawn out at the base. Poor chimney draft conditions and some fuels require an intermediate damper position, which causes a greater proportion of smoke to leave from the top of the firebox. An oil or gas burner works well with the damper in the vertical or an intermediate position.

When an oil or gas burner is used exclusively, as in the summer, the damper should be in the horizontal position. This will slightly increase efficiency by causing the flue gases to travel a longer path through the solid-fuel fire box before leaving the boiler.

The oil-gas combustion chamber is similar to that of other modern boilers. It is surrounded by water on all sides, including the bottom. This "wet base" design allows for greater heat transfer to the water. Equipped with a flame retention oil burner, this boiler will operate at an efficiency of up to 84%.

Domestic Hot Water

OT boilers have a tankless system for the production of domestic hot water. They can supply ample hot water for large homes with several bathrooms. The tankless coil is ¾" copper tubing and can convert the entire output of the boiler to hot domestic water.

Controls & Accessories

HS Tarm Type OT boilers are manufactured for use with standard American central hot water heating systems. All threaded tappings accept standard American controls and equipment.

All boilers are supplied with the following:
—Automatic draft regulator for the wood fire
—Cast iron grates
—Cleaning tools
—Built-in glass-lined tank for domestic hot water
—Insulated jacket with orange-red baked enamel finish
—ASME pressure relief valve for boiler
—ASME pressure relief valve for hot water coil
—High limit (overheat) control

In addition, a complete package of controls and accessories including an oil or gas burner is available with the boiler.

The boiler body is shipped on a pallet and has a lifting ring on top for ease of handling. The jacket and controls are packaged separately from the boiler body.

Construction

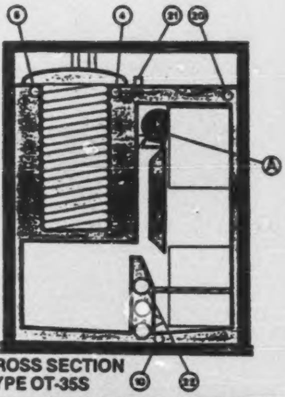
The steel plate used in the Type OT boiler is unusually heavy. All plate that is exposed to flue gasses is over ¼" in thickness. Insulation fully lines the jacket, which is finished in an attractive orange-red baked enamel.

5-Year Limited Warranty

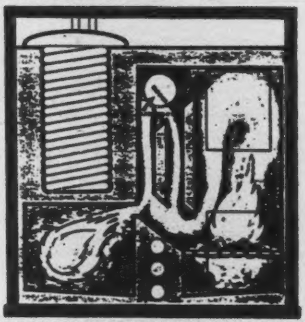
This boiler has a limited warranty, a copy of which is provided with the boiler and is available from your dealer.

For specific information in connection with the OT Series boilers, read the OPERATING AND INSTRUCTION MANUAL that accompanies the boiler and is available from your dealer.

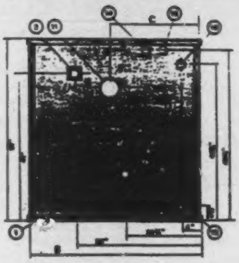
NORTHEAT WOOD STOVES, INC.
1306 Chugach Way
Anchorage, AK 99503
(907) 276-3972



CROSS SECTION TYPE OT-35S



CROSS SECTION TYPE OT-50S, OT-70S



REAR VIEW

Specifications

TYPE		OT-28S	OT-35S	OT-50S	OT-70S
Gross Output—Oil	Btu/hr	112,000	140,000	200,000	280,000
Gross Output—Wood	Btu/hr	72,000	112,000	140,000	196,000
Max. Hot Water Output	GPM	2.3	2.8	4.0	5.7
Output with 3 Elect. Heaters	KW	15	21	21	27
Width (B)	in	35¾	39½	46¾	46¾
Depth	in	24¾	30	30	39½
Length of Wood Chamber	in	15½	21½	21½	31
Width of Wood Chamber	in	7¾	10½	13¼	13¼
Wood Loading Door	in	7X10	10x12	10x12	10x12
Height up to Middle of Flue Outlet (H)	in	38½	38	37½	37½
Distance (C)	in	24	24½	25	25
1 Return	in	1¼	1¼	1¼	1½
2 Flow	in	1¼	1¼	1¼	1½
4 Tapping Triple Hot Water Control	in	¾	¾	¾	¾
5 Tapping for Tridicator	in	¾	¾	¾	¾
10 Extra Tapping	in	½	½	½	½
11 Flue Outlet (Outer Diam.) (D)	in	6	6	8	8
14 Hot Domestic Water	in	¾	¾	¾	¾
15 Cold Domestic Water Supply	in	¾	¾	¾	¾
16 Extra Tapping	in	1¼	1¼	1¼	1½
18 Boiler Drain Tapping	in	1	1	1	1
20 Tapping for Draft Regulator	in	¾	¾	¾	¾
21 Vent Tapping	in	½	½	½	½
22 Electric Element Tapping	in	2	2	2	2
Water Capacity—Boiler w/Coil	Gal	73½	76	91	130
Weight Boiler with Jacket	lb	946	1089	1444	1800
Pressure Test—Boiler	psi	72	72	72	72
Pressure Test—Hot Water Coil	psi	250	250	250	250
Minimum Flue Size	in	8X8	8x8	8x8	8x12
Minimum Chimney Height	ft	20	20	20	20

All specifications are subject to change without notice.

The responsibility for determining compliance with local and state codes is the obligation of the dealer.

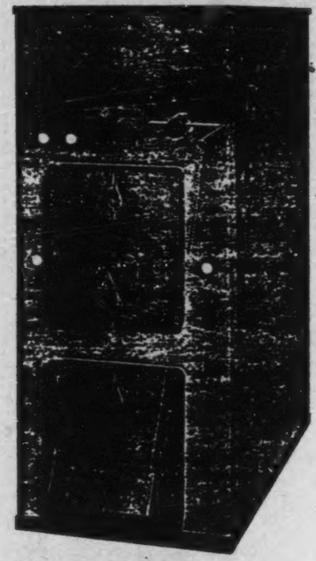
Note: Adequate chimney draft is required for proper operation of all wood-fired boilers. Please observe minimum chimney requirements in the table above.

HS • TARM

Tekton Corporation
Conway, MA 01341 (413) 369-4367

The Type OT boiler is approved by the Energy Testing Laboratory (Portland, Maine) and the Massachusetts Fire Marshal's Office.

HS•TARM TYPE MB-Solo Wood/Coal Boiler



General Information

The HS Tarm Type MB-Solo is a new multi-purpose boiler for hot water heating systems. The MB-Solo is equipped to burn wood or coal, or can be supplied as an oil- or gas-fired boiler. Whichever model you choose, the MB-Solo gives you flexibility.

Installed as a solid fuel-fired boiler in combination with an existing oil- or gas-fired boiler, it allows you to heat your entire house and tap water by burning wood or coal. At your discretion, solid fuel may be relied upon to supply all your home's heat or merely part of it. If the fire should die down or be allowed to go out, automatic controls will activate the oil or gas burner on your present boiler to guarantee uninterrupted heat.

Installed by itself as an oil- or gas-fired boiler, the MB-Solo can be converted easily to operate on solid fuel — thus protecting you in the event of a power failure or interruption in your supply of oil or gas. And even if you never need to burn solid fuel, the MB-Solo operates as efficiently on oil or gas as any modern single-fuel boiler.

The MB-Solo's firebox is of generous size, with large cast-iron doors to facilitate wood loading and ash removal. The wood fire is controlled by a non-electric automatic draft regulator, which will safely maintain boiler temperature even during power failures.

Because the MB-Solo gives you the option of substituting firewood for costly commercial fuel, it makes possible dramatic reductions in fuel costs. And because it ends your absolute dependence on oil or gas, it provides security against shortage of these increasingly scarce fuels.

Combustion

The MB-Solo's firebox employs a base-burning arrangement which maximizes efficiency of solid-fuel combustion. As wood or coal is heated in any fire, it emits compounds, which, when burned, yield heat. When these compounds are not burned, they can represent a significant loss of efficiency. They can also produce soot or creosote, a tar-like deposit formed by the condensation of some flue gases when they are cooled. The MB-Solo's base-burning principle encourages burning of these compounds. The smoke leaves the boiler at the lower rear of the firebox, where flammable gases are drawn over the fire's hot coals. Additional air to aid in the combustion of these gases is provided by the air inlet in the upper door of the firebox and by the secondary air dial on the right side of the boiler. This secondary air dial meters air to a manifold at the bottom rear of the firebox (#26 on the side view diagram). The manifold preheats and injects this air into the hot gases leaving the firebox, enabling secondary combustion of otherwise unburned compounds in these gases to occur.

The MB-Solo is available in two different configurations for operation on oil or gas. For long-term service on these fuels, a burner plate is used in place of the upper firing door and a conversion plate is substituted for the grates. Where quick changeover between solid fuel and oil or gas is desired, the boiler can be supplied with a special door in place of the upper firing door. This "double-swing door" is a door frame with a solid-fuel firing door hinged to the right and a burner-mounting door hinged to the left. By swinging one door out and the other in, either type of fuel may be used on a moment's notice.

The firebox is surrounded by water on all sides and the bottom. This "wet-base" design allows for greater heat transfer, helping the MB-Solo to burn wood, coal, oil or gas with a high degree of thermal efficiency.

Due to the fact that the firebox is surrounded by water, the firebox walls are maintained at a relatively cool (200° F.) temperature. The low temperature of these walls precludes the use of wood with more than 20% moisture content. Use of such "green wood" will result in poor burning and excessive formation of creosote and soot. Well-seasoned wood is required for proper boiler operation.

Controls & Accessories

HS Tarm Type MB-Solo boilers are manufactured for use with standard American central hot water heating systems. All threaded tappings accept standard American controls and equipment.

All boilers are supplied with the following:

—Automatic draft regulator for the wood fire
—Cast iron grates
—Insulated jacket with orange-red baked enamel finish
—ASME pressure relief valve for boiler
—High limit (overheat) control
—Cleaning tools

For operation on oil or gas, one of the following is required:

—Double-swing door

—Burner plate and conversion plate

In addition, the boiler is available with the following options:

—Tankless coil for domestic hot water

—Coal grates for burning coal or coke

The boiler is shipped on a pallet and has a lifting ring on top for ease of handling. The jacket and controls are packaged separately.

Construction

The steel plate used in the MB-Solo boiler is unusually heavy. All plate that is exposed to flue gasses is over ¼" in thickness. We invite comparison of the MB-Solo's total weight to that of any similar product.

Insulation fully lines the jacket, which is finished in an attractive orange-red enamel.

5-Year Limited Warranty

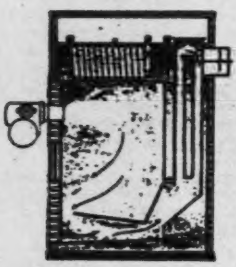
The HS Tarm Type MB-Solo has a limited warranty, a copy of which is provided with the boiler and is available from your dealer.

For more detailed information in connection with the HS Tarm Type MB-Solo, please read the OPERATING AND INSTRUCTION MANUAL that accompanies the boiler and is available from your dealer.

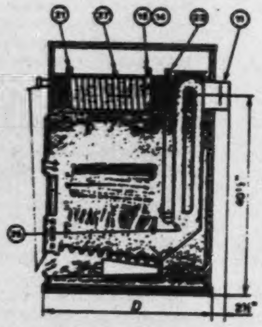
Specifications

Type MB-Solo		30	40	55	75
Gross Output—Wood	Btu/hr	72,000	100,000	140,000	180,000
Gross Output—Oil	Btu/hr	120,000	160,000	220,000	300,000
Domestic Hot Water Output (Wood)	GPM	1.5	2.0	2.9	3.7
Width (B)	in	17¾	17¾	21	21
Length (D)	in	29¼	29½	41½	41½
Width of Firebox	in	12½	12½	18½	18½
Length of Firebox	in	15½	15½	27½	27½
Distance (C)	in	8¼	8¼	11¼	11¼
1 Return	in	1½	1½	1½	1½
2 Flow	in	1½	1½	1½	1½
4 Tapping for Tridicator	in	¾	¾	¾	¾
5 Tapping for Aquastat	in	¾	¾	¾	¾
10 Extra Tapping	in	½	½	½	½
11 Flue Outlet (O.D.)	in	6	6	6	6
14 Hot Domestic Water	in	¾	¾	¾	¾
15 Cold Domestic Water Supply	in	¾	¾	¾	¾
16 Extra Tapping	in	1	1	1	1
18 Boiler Drain Tapping	in	1	1	1	1
20 Tapping for Draft Regulator	in	¾	¾	¾	¾
21 Extra Tapping	in	½	½	½	½
23 Tapping for Overheat Control	in	¾	¾	¾	¾
24 Preheated Secondary Air Control		X	X	X	X
25 Preheated Secondary Air Manifold		X	X	X	X
27 Vent Tapping	in	⅜	⅜	⅜	⅜
Door Size	in	10x12	10x12	10x12	10x12
Water Capacity	Gal	29	36	55	55
Weight-Boiler w/jacket	lb	694	770	1100	1177
Pressure Test-Boiler	psi	72	72	72	72
Pressure Test-Coil	psi	250	250	250	250
Minimum Flue Size	in	8x8	8x8	8x12	8x12
Minimum Chimney Height	ft	20	20	20	20

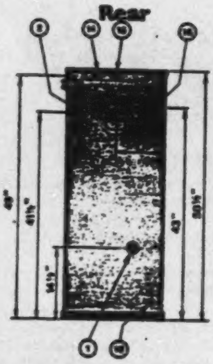
Cross Section
oil or gas combustion



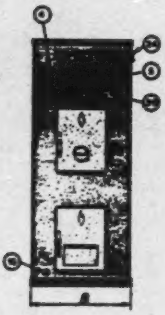
Cross Section
solid fuel operation



Rear



Front



All specifications are subject to change without notice.

The responsibility for determining compliance with local and state codes is the obligation of the dealer.

Note: Adequate chimney draft is required for proper operation of all wood-fired boilers. Please observe minimum chimney requirements in the table above.

HS • TARM

Tekton Corporation
Conway, MA 01341 (413) 369-4367

NORTHEAT WOOD STOVES, INC.
1306 Chugach Way
Anchorage, AK 99503
(907) 276-3972

The Type MB-Solo boiler is approved by the Energy Testing Laboratory (Portland, Maine) and the Massachusetts Fire Marshal's Office.

Selection for Atkasook:

As a pilot project a number of HS-TARM OT-35S are being installed in Atkasook by the NSB.

Present use of stoves and furnaces:

In order to investigate which types of furnaces and stoves are presently in use in the village, several houses have been inspected. Based on these visits and on personal discussions, the three following fundamentally different heating systems were found:

1) Heat provided by a single, centrally placed stove
2) Heat provided from a furnace by means of circulating air
3) Heat provided from a furnace by means of a water/glycol mixture.

Applicability of multi-fuel and add-on furnaces:

Coal fired furnaces ought to be placed in a separate room in order to minimize the inconveniences due to dust. Therefore, the bigger and newer houses with more rooms, which typically already have their furnace placed in a separate room, are more apt to have a multi-fuel or add-on furnace installed, than are the old, typically one-room houses.

With limitations, i.e. forced air vs. water glycol distribution, due to the technical specifications, all of the above listed multi-fuel and add-on furnaces can be installed in the newer multi-room houses in Wainright, while none of these are considered suitable for the older houses. For these, traditional coal stoves may be considered as an interim alternative.

The multi-fuel furnaces are not compatible with a district heating system since the district heating system will provide heat to the houses by means of heat exchangers. So, unless they are kept as backup for emergency situations, e.g. a shut-down of the district heating center, their value will be close to zero, once the district heating system is installed and in operation.

Recommendations:

If the NSB decides to go ahead with the district heating scheme, the operation life of add-on furnaces will be rather short and therefore unproportionally expensive. So, in this case we do not recommend add-on furnaces to be installed.

If, on the other hand, NSB decides to postpone the implementation of the district heating system, but still go ahead with the coal mine development and installed add-on furnaces and dual-fuel furnaces thus can be expected to have a reasonable long service life, we recommend one of each of the following furnaces to be installed as a pilot project:

1) HS-TARM TYPE MB-SOLO as add-on furnace in a home with a water-glycol filled base board system and with the existing oil burner placed in a separate room.

2) CWF as add-on furnace in a home with a forced air heating system and with the existing oil burner placed in a separate room.

3) HS-TARM TYPE OT as dual-fuel furnace in a new home to be built. This house to be equipped with the water-glycol base board system and a separate room for the furnace.

It should be noticed that all new homes should be built with the water-glycol filled base board system, since the connection to the district heating system's heat exchangers then will be easier and less expensive.

A program for checking future coal consumption against past and present oil consumption in lbs., gallons, and dollars must be established. This program shall also monitor the alternative furnaces' output as well as the occupants' comments on inconveniences, constraints, etc.

Literature references

1. Elissa R. Krzeminski: Central heat from wood and coal. New Roots. Harvest 1981.

2. Allana M. Sullivan: Coal heats homes as oil prices rise. Coal Age. August 1980.

3. Eb Rice: Building in the North.

4. C. L. Baumbach: Fyringi to-kammerkedler (Combustion in multi-fuel furnaces). Fyring, No. 4-1979.

5. Miscellaneous technical brochures.

10.0 VILLAGE VIEWS

The work plan for the current study provides, that the views of the people of Wainwright should be ascertained before final recommendations are made.

To this end the village was visited by Fenton Rexford and Gosta Bursell on November 17, 1981. At a well attended Public Meeting the study conclusions were explained and 3 copies of the draft report were left with the Council.

It was explained, that the study team would visit Wainwright again in January 1982 to ascertain the village people's views on the report conclusions for incorporation into the final report. A Public Hearing was arranged for January 26, 1982. This was attended by Ray Spandura, representing Department of Public Works, NSB, Fenton Rexford, Steve Rog, Mogens Bastrup and Gosta Bursell, representing the consultants. This meeting was poorly attended and the views expressed were inconclusive.

One concern was identified, namely that the heating distribution system as proposed might prevent the free use of snowmobiles away from the roads in the village.

The question has been raised in the NSB comments to the Draft Report, whether village people are at all prepared to work in an underground mine.

When putting this question at the Public Hearing no response was forthcoming.

It is evident to the consultants, that a much greater efffort than that averaged or budgetted for will be required to create a sufficient degree of Public Awareness in order to prepare the ground for a qualified response to the questions raised.

With the concurrence of the NSB representatives at a meeting held in Barrow January 27, 1982 a public awareness program is being included in the scope of a proposal regarding further preconstruction work.

This program will include:

- A possible visit by some Wainwright people to an underground mine.
- Educational films on underground coal mining.
- Cutaway model of the mine and district heating system, related to the village.
- Slides and wall plans.
- Door to door visits with a questionnaire together with the NSB village coordinator.

11.0 CONCLUSIONS AND RECOMMENDATIONS

11.01 Recommendation of Initial Feasibility Study

The recommendation of the initial feasibility study report of July 31, 1980 as regards generation and heating method was that further consideration be given to alternatives A-1, A-II and A-2.

11.02 Alternative A-2

Provided for generating sufficient electric power to enable all space heating to take place by electric resistance heating, at the same time as other electric power and lighting needs are met.

This alternative taken by itself is not economical as can be seen in the schedule in Section 8.05.3. It is wasteful in its principle in that waste heat would be spilled into the air, the sea or the Kuk River. The thought that the waste heat could be used for heating greenhouses has been briefly investigated, but it was found that the likely local market for greenhouse produce is so insignificant in relationship to the energy wasted that we recommend this alternative should be disregarded without any further work being done on it.

11.03 Alternative A-1.

This alternative provides for utilizing waste heat from a counter pressure steam turbine for reheating part of the heating fluid required for space heating.

We have found during the course of the current study that we had previously under-estimated the extent to which waste heat must be supplemented by direct firing to meet all heating demands.

In review, the position is as shown in Section 8.05.3.7. It will be seen from the summary that alternative A-1 is less economic than either alternative A-II or the A-II-A alternatives (A-II with ORC-generation).

Also, alternative A-1 suffers from the disability that it calls for licensed boiler operators, which would create problems which both the Utilities Department and the village people would want to avoid.

Briefly, these problems involve a higher level of technology which would mean:

- the permanent employment of 4-6 technicians from outside of the level of licensed boiler operator or
- the training of village people in far away locations over extended periods (2-3 years) with the concommittent danger, that the trainees would end up staying away after completed training.

11.04 Alternative A-II

The aforementioned eliminations leave Alternative A-II as the recommended method of providing central district heating for Wainwright. Briefly summarized, Alternative A-II provides for reheating the recirculated heating fluid by means of low-pressure coal-fired water heaters as a pressure just below 15 psig and at an outlet temperature of 210°F. By means of an insulated distribution network the heating medium would transfer space heating energy to the buildings in the village.

Electric power and lighting would continue to be provided by existing diesel generating equipment.

11.05 Organic Rankine Cycle Generators.

In Section 8.0, we have examined the costs and benefits of supplanting diesel electric generation with Organic Rankine Cycle Generators heated by coal-fired low pressure water heaters.

This examination has been called for by the North Slope Borough because it had reservations about planning for the continued use of diesel fuel for generating electricity.

The result of this examination is our recommendation that ORC generation should not be implemented at this time on account of inferior economy as compared to continued reliance on diesel generation, also because the experience background for ORC generation is very limited at this stage.

This state of affairs may very well change after some years. Consequently, it is recommended that consideration be given to making provision in the buildings and systems for the later addition of ORC generators to supplant diesel generation.

It is noted that the Alaska Power Authority is funding a 300 KW ORC generator pilot plant using a solid fuel as prime energy and to be sited in a village in Northwest Alaska.

We recommend that NSB should consider seeking to have this pilot plant sited at Wainwright.

The above recommendations are put forward subject to what is said in the following section about an electrical transmission intertie involving Barrow, Atkasook and Wainwright.

11.06 Transmission Intertie Between Barrow, Atkasook and Wainwright

The North Slope Borough has commissioned a study entitled "Project Planning Report, Barrow - Atqasuk - Wainwright Transmission Line", performed by Jack West Associates and others, which was submitted to the North Slope Borough in September 1981.

The main conclusion of this report was: "An electric transmission line intertie of Barrow, Atqasuk and Wainwright is technically feasible and economically beneficial to the NSB."

The 20-year energy cost was estimated to be as follows:

	Wainwright continued Intertie	Diesel gen
1982	15¢/kwh	42¢/kwh
1985	17¢/kwh	50¢/kwh
1990	23¢/kwh	66¢/kwh
1995	31¢/kwh	88¢/kwh
2000	42¢/kwh	1.19¢/kwh

The development of such an intertie would fit in extremely well with the main recommendations we have made in this study.

Moreover, if at any time the natural gas reserves near Barrow are depleted or are priced closer to national market prices. The intertie would allow a flow of electric energy from Wainwright based on coal-fired generation of electricity on a regional basis.

11.07 Wind Generation

Another possible way of saving on diesel fuel consumption under the recommended Alternative A-II would be the installation of one or more wind generators.

Modern wind generators have an experience rating on a par with ORC generators, but they have the advantage in this case of utilizing a renewable energy source.

It is known to us that the village of Kaktovik with the assistance of NSB are planning to install a pilot wind generator of either 10 KW or 50 KW.

It is recommended that the results from the Kaktovik pilot wind generator be followed carefully in order to assess whether wind generators would be a candidate technology under the prevailing conditions for saving diesel fuel.

11.08 Energy Conservation

The space heating demand forecasts which were developed during the initial study were based on projections from an assessment of the heating needs of the buildings in Wainwright in the condition in which they were found at the time.

There is no doubt that space heating demand would be a good deal lower, perhaps as much as 30% lower, if a program of energy saving building improvements were to be defined and implemented.

It is recommended that such a program be thoroughly investigated.

It is not, at this time, suggested that detailed design should be based on a reduced demand resulting from conservation measures. Rather, it is suggested, that savings in demand can serve to put off the day when increased capacity will have to be provided to take care of increases in demand, which will be occasioned by an increase in population and a per capita increase in energy consumption resulting from a higher standard of living.

12.0 CONCEPTUAL PLAN FOR RECOMMENDED ALTERNATIVE

12.01 The recommended long-term plan is made up of the following main components:

- An underground mine with a 788 ft. long incline entry and an 8 ft. diameter exhaust shaft and escape manway, as shown on Figures 4.3.1, 4.3.2 and 4.3.3., volume 3.

- A minemouth complex connected to the incline entry by a covered passage as shown in master plan 12.3, following.

  The complex consists of

  - Off loading and loading area
  - Bulk coal storage
  - Boiler room
  - Provision for later addition of ORC-generators (if required)
  - Heated bays for diesel equipment
  - Workshop area
  - Office and staff facilities
  - Storage for diesel fuel and antifreeze.

- Access road to the minemouth complex from Wainwright village, 2,500 ft. long as shown on Map 12.1, following.

- Distribution network and mains for supplying heating fluid to buildings in Wainwright as shown on Map 12.2, following

- Transmission line to connect minemouth complex and mine with existing electrical transmission network.

- Existing diesel generation plant will continue to be used for electrical power and lighting needs. The existing capacity, three 250 KW generators, should be sufficient to cover the power requirements of the mine and the minemouth complex, along with the village demand.

12.02 Underground Mine

The underground mine, its design and its operation has been fully described in Volume 3.

12.03 Minemouth Complex

The minemouth complex, plan 12.3 is connected to the incline entry by a covered passage, which opens to a covered off-loading and loading area.

At the coal face a continuous miner mines and loads the coal onto a shuttlecar, which transports the coal to the off-loading area in the complex, where the coal is dumped into a hopper and transported by a conveyor to the stock pile.

In order to quell any incidence of spontaneous combustion by denying oxygen supply the stockpile may be kept under an airtight plastic tent. This would also serve to reduce coal dust pollution in and around the storage building.

The loading area and the bulk storage is located in an unheated building. Coal is withdrawn from the stockpile by a frontloader, which loads a hopper feeding a conveyor from which the coal is fed into a bunker.

From the bunker the coal is withdrawn by screw-transporters and fed to the stokers on 2 low-pressure heaters. Ash is discharged into an ashpit and thence to an ash storage bin for later removal to a dump. In a heat exchanger, the flue gases reheat a heating fluid returning from the village. Thereafter, the flue gases pass through a cyclone before being discharged into open air from a stack.

The boiler room also contains supporting systems such as:

- Topping up arrangements for water and antifreeze.
- Circulation pumps for heating fluid.
- Pressure equalization tanks for heating fluid.
- Control panel.
- Standby diesel generator.
- Overhead gantry crane.

The minemouth complex could, if required, contain provision for two 300 KW ORC generators together with necessary additional heater capacity, which could at a future date supplant diesel generators as a source of electrical energy.

A service section provides:

- workshop area
- bays for diesel equipment (heated)
- offices and secretarial space
- 10-man shower facilities
- lunchroom
- toilets
- storage for diesel drums and antifreeze.

On the pad, there is provision for outside storage and parking, and space is provided for future condenser coolers in the event ORC generators are installed.

Plans and main building features are shown in enclosed drawings:

Drawing No.	Title
12.4	Plan view
12.5	Typical cross section
12.6	North and West elevations
12.7	South and East elevations
12.8	Bird's eye view

12.04 Access Road

An all weather road will be required to connect the mine and minemouth complex with the village.

Plan 12.9, following, shows a section through the road, which also serves as a service road for the heating fluid mains and the power transmission line connecting the minemouth complex and the village distribution networks.

12.05 Distribution network and mains for heating fluid

The distribution network and mains are shown on Maps 12.1 and 12.2. The concept for this system is essentially as described in the initial feasibility study, subject to variations to meet concerns about snowmobile mobility off the roads.

12.06 Electrical transmission line

An electrical transmission line will be provided to connect the minemouth complex and the mine with the existing diesel generating station situated next to the secondary school.

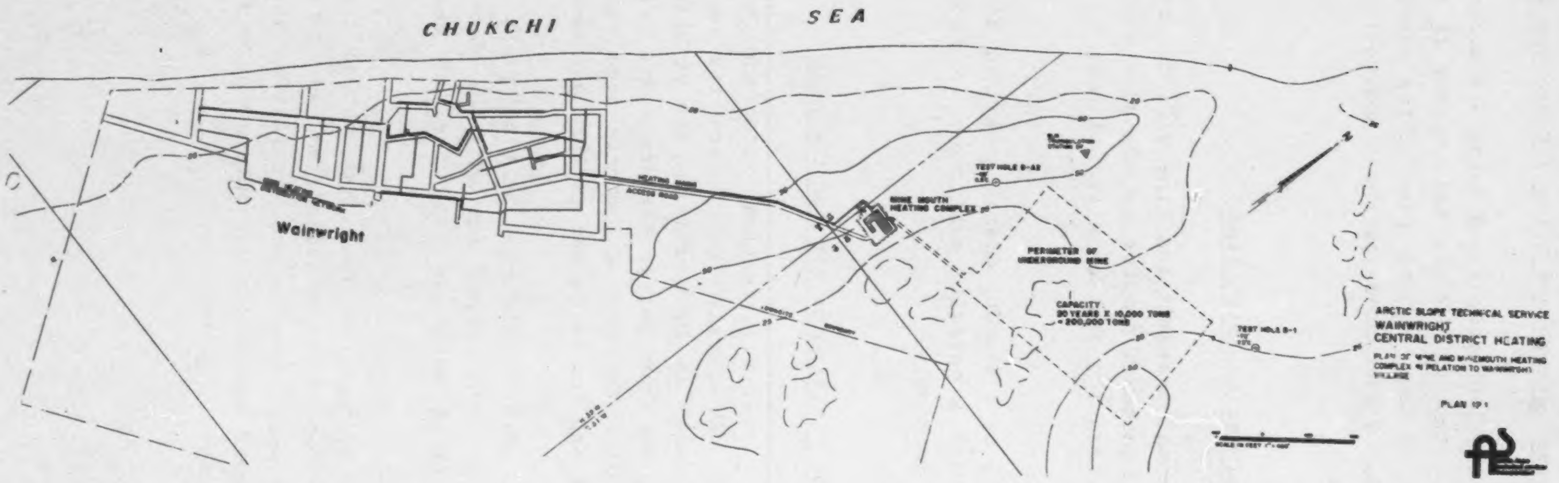
There will be a standby diesel generator at the minemouth complex with a capacity sufficient to cover the complex and mine load only.

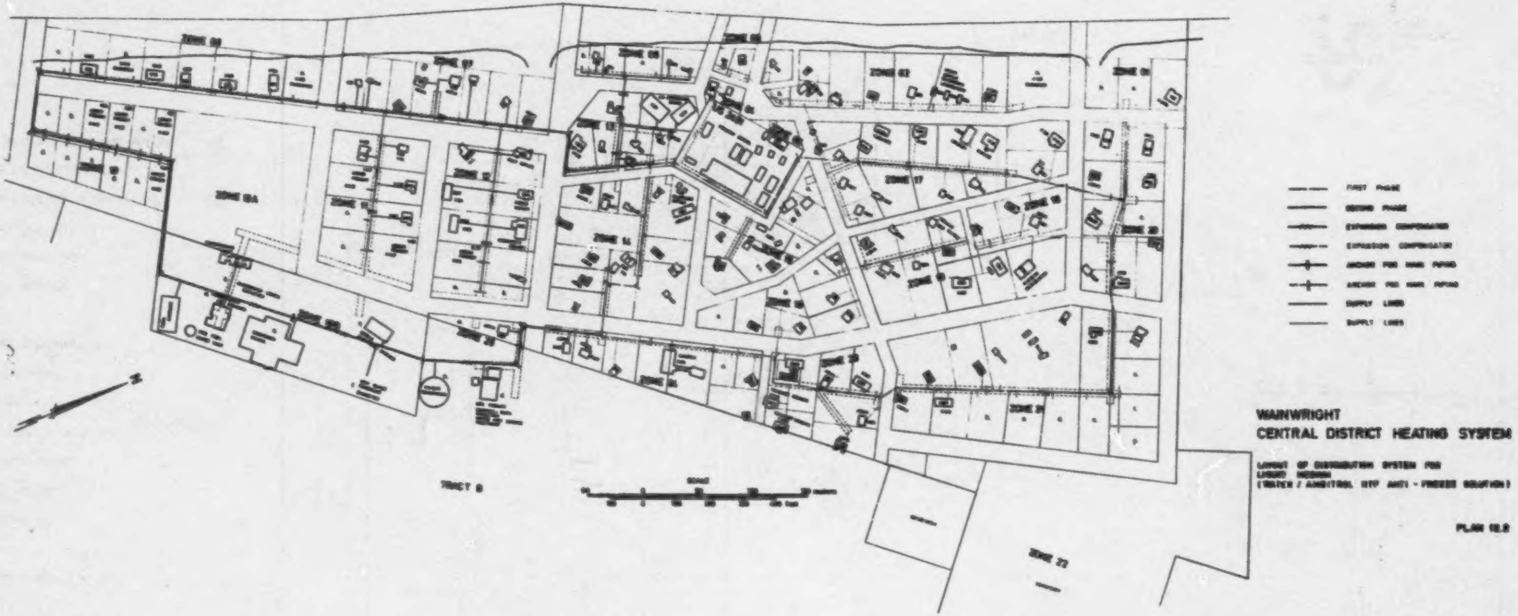
12.07 Heating of Ventilation Air for the Mine

For the interim situation when the mine is being developed and operated but before the central district heating system is in operation, the ventilation air will be heated by four Herman Nielsen space heaters, running on fuel oil. They are a commonly used type of builders equipment and can be leased at $120 per week each.

When the central district heating plant is installed, heating of ventilation air will be done by the same heating fluid which is used for the central district heating.

In order to save on fuel for heating the mine a heat exchanger would be installed, whereby exhaust air from the mine would preheat the ventilation air, so that the water-heated heat-exchanger only would be required to top up the energy required.


CHUKCHI
SEA
Wainwright
HEATING MAINS
ACCESS ROAD
MINE MOUTH
HEATING COMPLEX
TEST HOLE 8-A2
PERIMETER OF
UNDERGROUND MINE
CAPACITY
20 YEARS X 10,000 TONS
= 200,000 TONS
TEST HOLE 8-1
20
N
ARCTIC SLOPE TECHNICAL SERVICE
WAINWRIGHT
CENTRAL DISTRICT HEATING
PLAN OF MINE AND MINEMOUTH HEATING
COMPLEX IN RELATION TO WAINWRIGHT
VILLAGE
PLAN 12-1

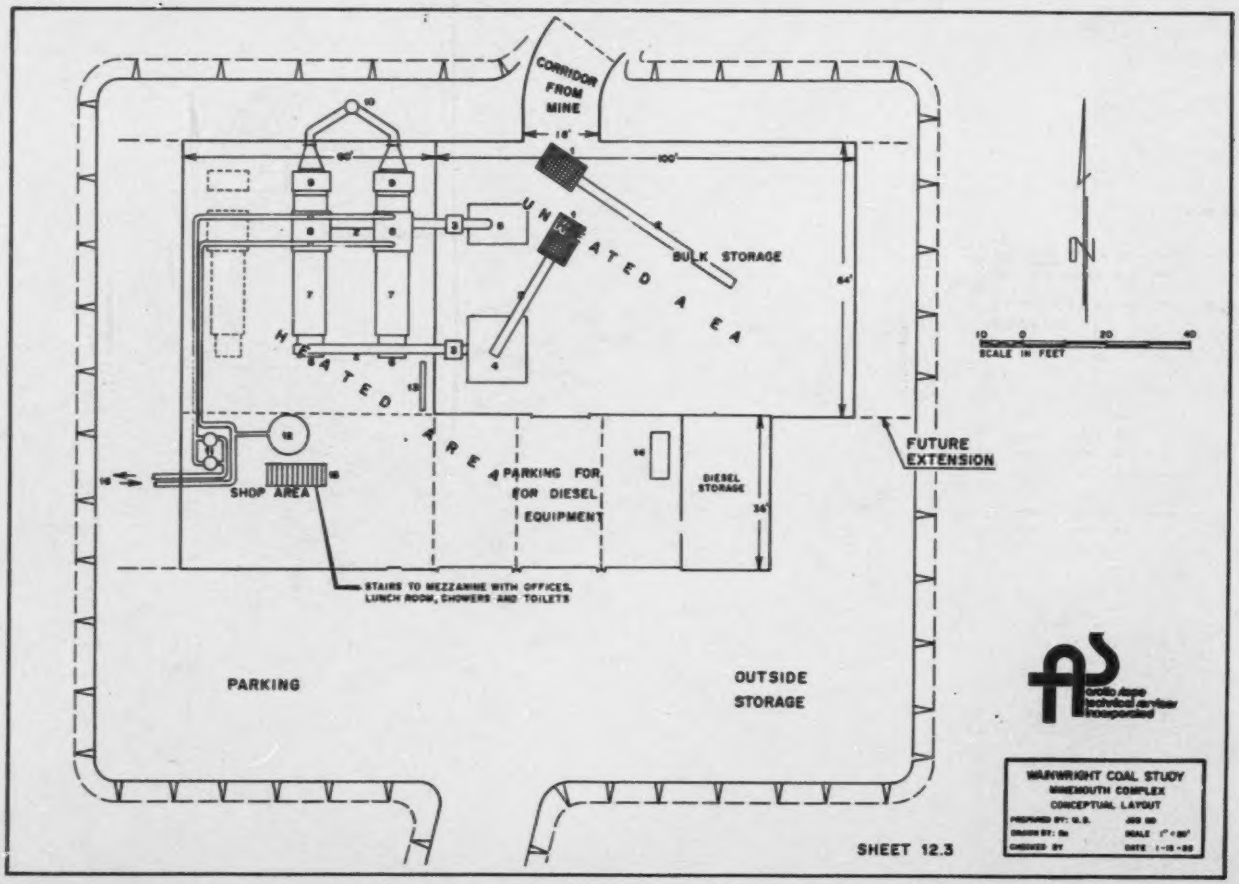

FIRST PHASE
SECOND PHASE
EXPANSION COMPENSATOR
EXPANSION COMPENSATOR
ANCHOR FOR MAIN PIPING
ANCHOR FOR MAIN PIPING
SUPPLY LINES
SUPPLY LINES
ZONE 22
ZONE 21
TRACT B
SCALE
N

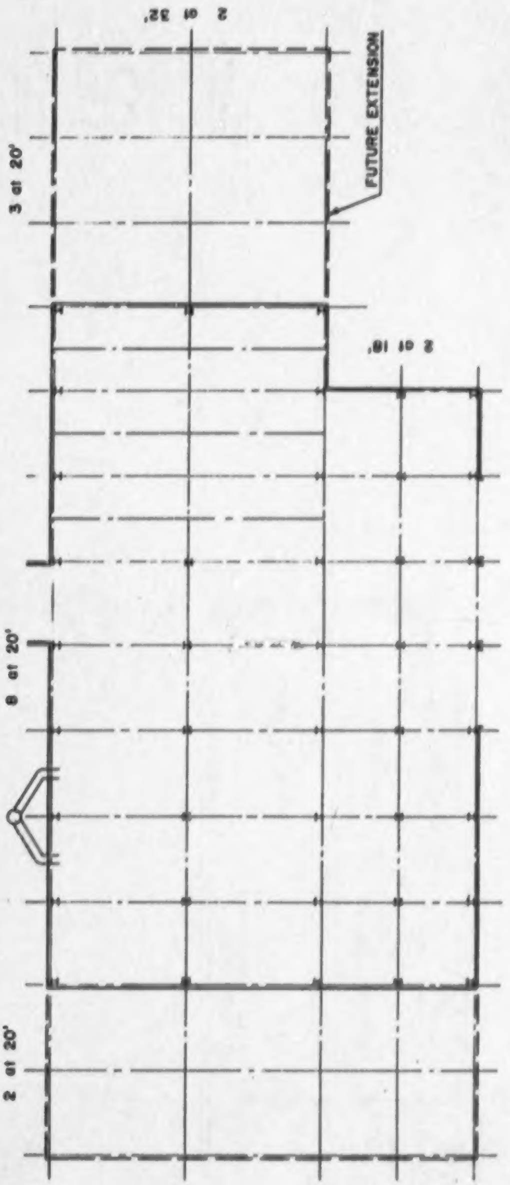
WAINWRIGHT
CENTRAL DISTRICT HEATING SYSTEM

LAYOUT OF DISTRIBUTION SYSTEM FOR
LIQUID MEDIUM
(WATER / AMBITROL STF ANTI - FREEZE SOLUTION)

PLAN 12.8

1. GRID AND HOPPER
2. CONVEYER
3. ELEVATOR
4. COAL BUNKER
5. ASH CONTAINER
6. COAL FEED TO STOKER
7. FIRE BOX
8. HEAT EXCHANGER
9. CYCLONE SEPARATOR
10. STACK
11. CIRCUIT PUMPS
12. EXPANSION VESSEL
13. CONTROL PANEL
14. STANDBY DIESEL GENERATOR
15. STAIRS TO MEZZANINE
16. DISTRIBUTION HEATING MAINS

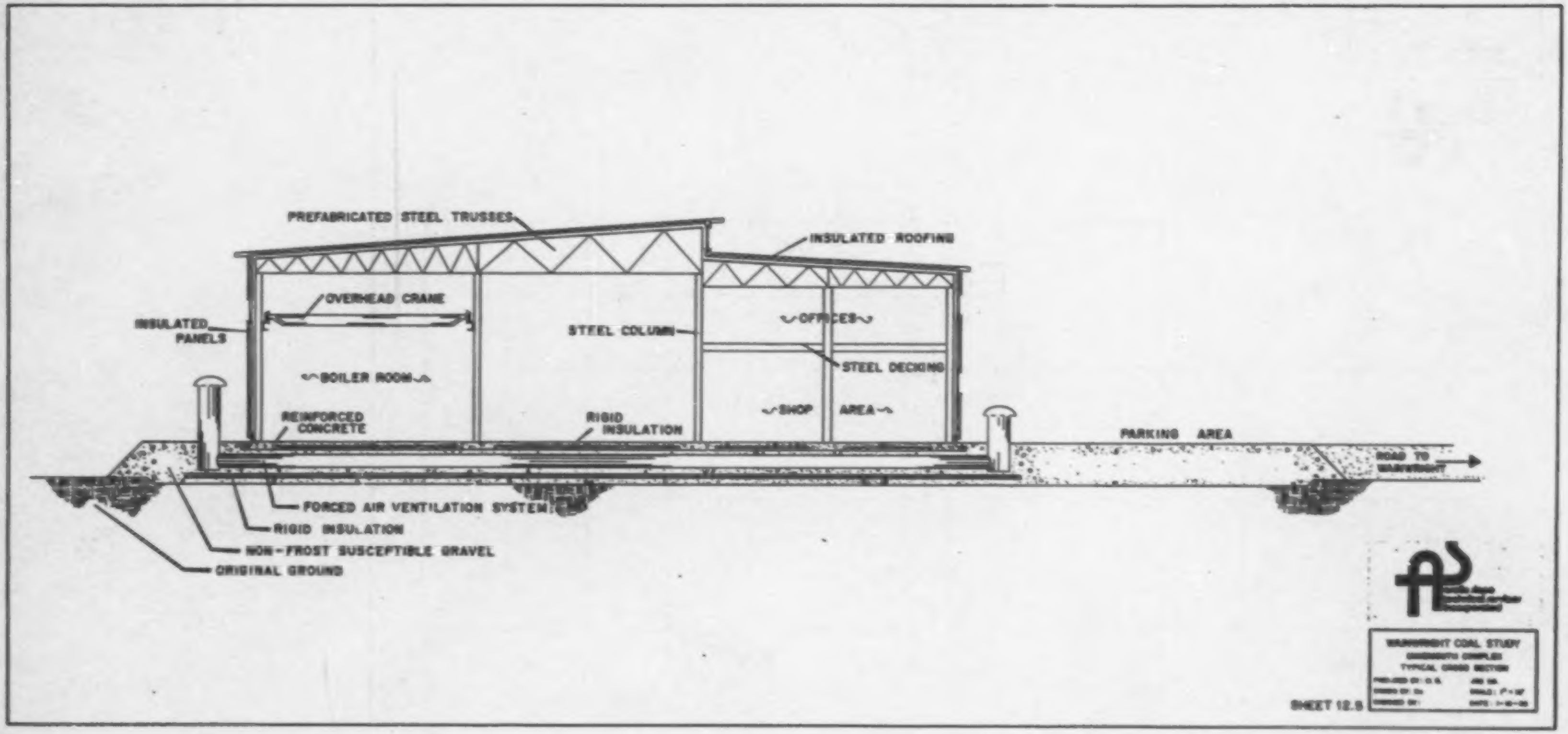

CORRIDOR FROM MINE
18'
90'
100'
64'
36'
BULK STORAGE
UNHEATED AREA
HEATED AREA
PARKING FOR FOR DIESEL EQUIPMENT
DIESEL STORAGE
SHOP AREA
STAIRS TO MEZZANINE WITH OFFICES, LUNCH ROOM, SHOWERS AND TOILETS
FUTURE EXTENSION
PARKING
OUTSIDE STORAGE
N
10 0 20 40
SCALE IN FEET
arctic slope technical services incorporated
WAINWRIGHT COAL STUDY
MINEMOUTH COMPLEX
CONCEPTUAL LAYOUT
PREPARED BY: G.S.
JOB NO
DRAWN BY:
SCALE
CHECKED BY
DATE
SHEET 12.3

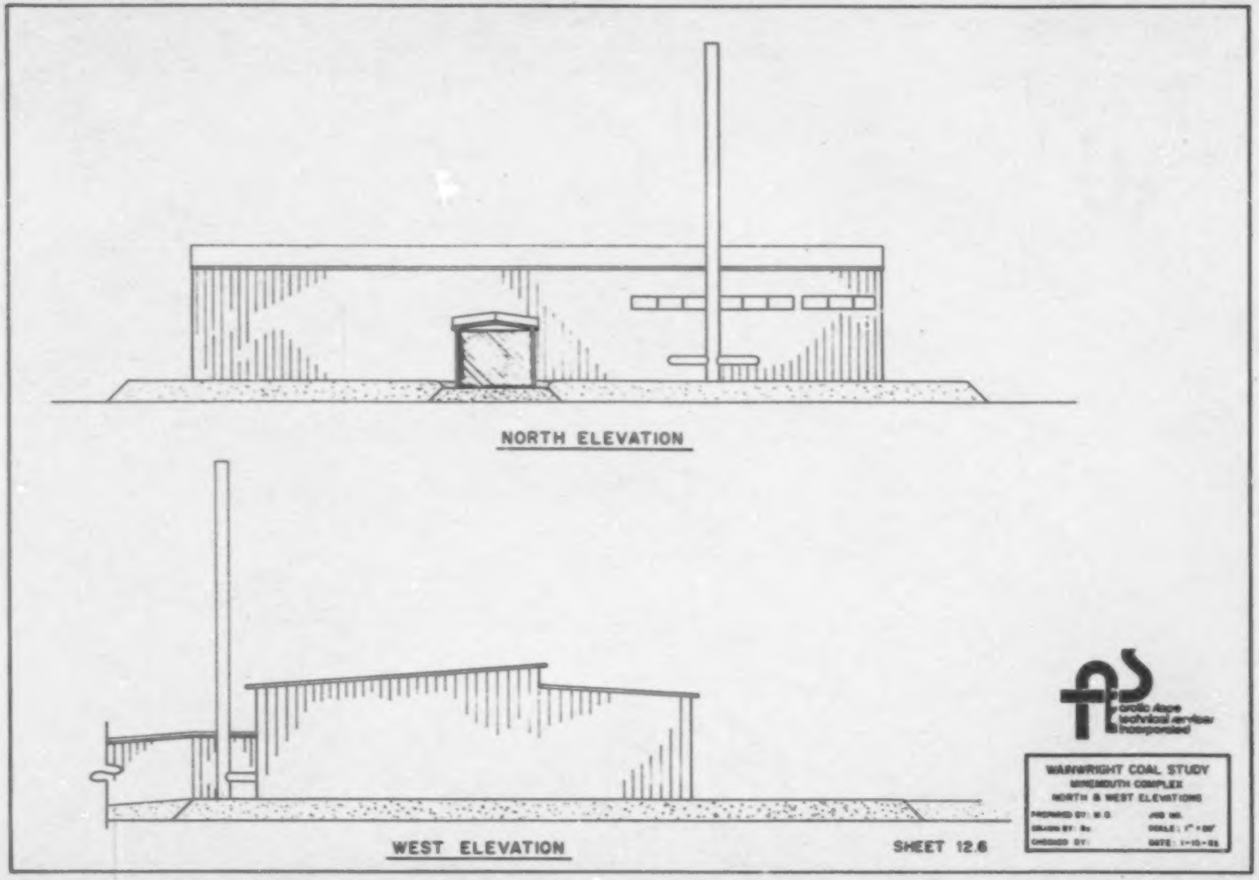

2 at 32'
3 at 20'
FUTURE EXTENSION
2 at 18'
8 at 20'
2 at 20'

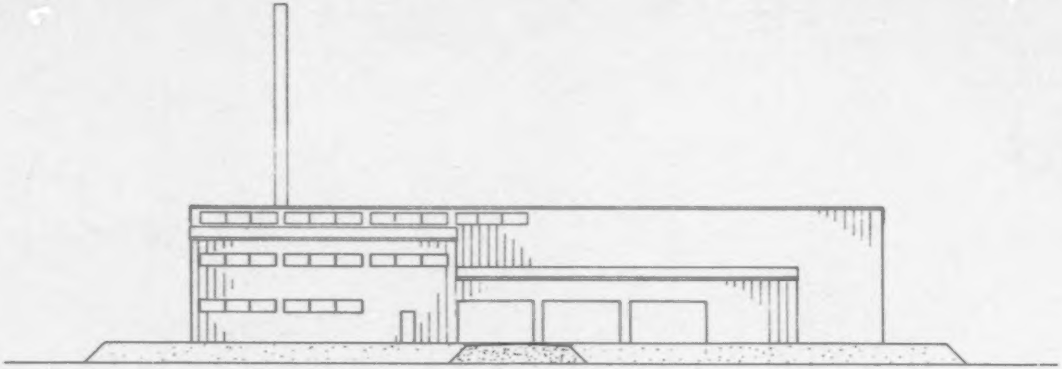
WAINWRIGHT COAL STUDY
[illegible] COMPLEX
PLAN VIEW

PREPARED BY:
DRAWN BY:
CHECKED BY:
JOB NO.
SCALE:
DATE:

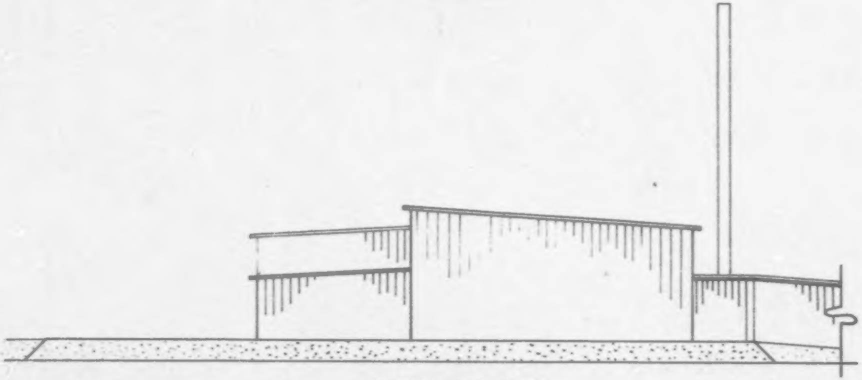
SHEET 12.4


PREFABRICATED STEEL TRUSSES
INSULATED ROOFING
OVERHEAD CRANE
INSULATED PANELS
STEEL COLUMN
OFFICES
STEEL DECKING
BOILER ROOM
SHOP AREA
REINFORCED CONCRETE
RIGID INSULATION
PARKING AREA
ROAD TO WAINWRIGHT
FORCED AIR VENTILATION SYSTEM
RIGID INSULATION
NON-FROST SUSCEPTIBLE GRAVEL
ORIGINAL GROUND
WAINWRIGHT COAL STUDY
TYPICAL CROSS SECTION
SHEET 12.9


NORTH ELEVATION
WEST ELEVATION
SHEET 12.6
arctic slope technical services incorporated
WAINWRIGHT COAL STUDY
MINEMOUTH COMPLEX
NORTH & WEST ELEVATIONS
PREPARED BY:
JOB NO.
DRAWN BY:
SCALE:
CHECKED BY:
DATE:



SOUTH ELEVATION



WEST ELEVATION

SHEET 12.7

arctic slope
technical services
incorporated

WAINWRIGHT COAL STUDY
MINEMOUTH COMPLEX
SOUTH & EAST ELEVATIONS

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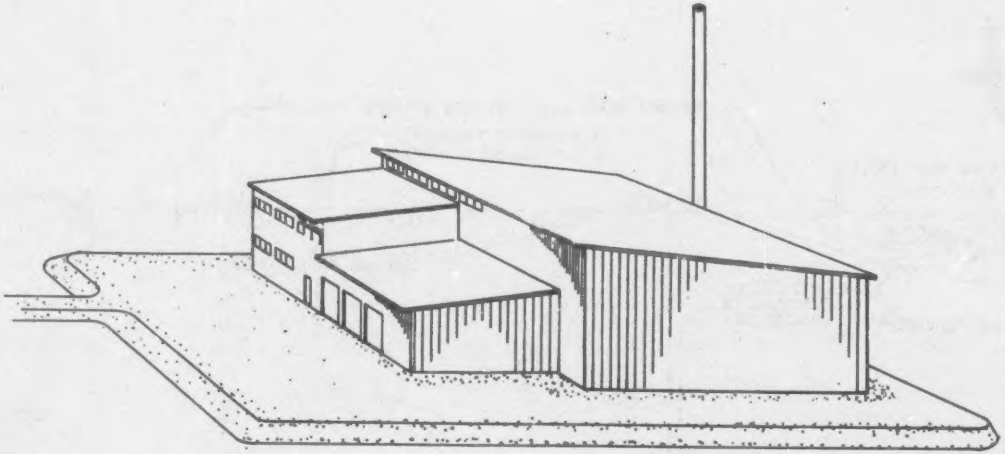
DRAWN BY Bu SCALE: 1" = 20'
CHECKED BY DATE: 1-10-82



SHEET 12.8

WAINWRIGHT COAL STUDY
MINEMOUTH COMPLEX
BIRD'S EYE VIEW

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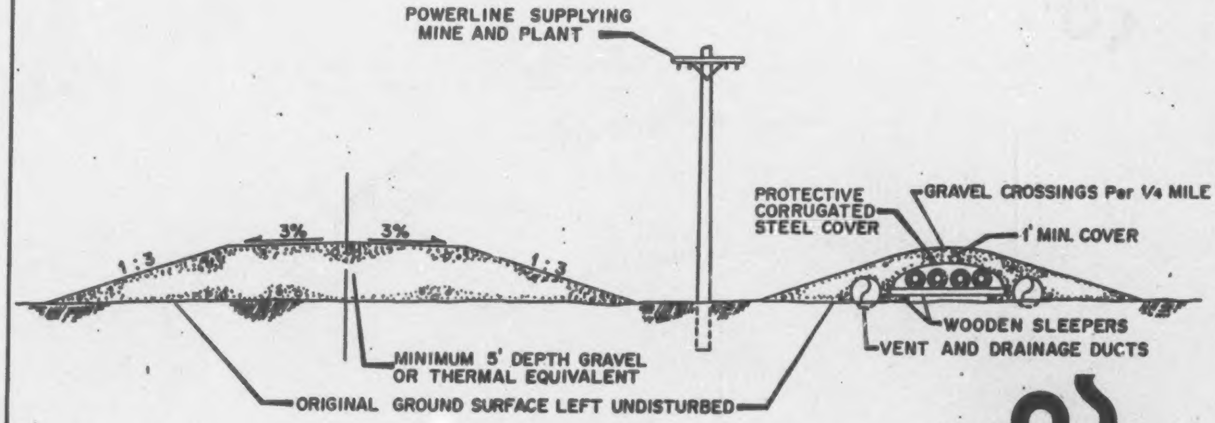
DRAWN BY: [illegible] SCALE: 1" = [illegible]
CHECKED BY: DATE: 1-[illegible]-[illegible]

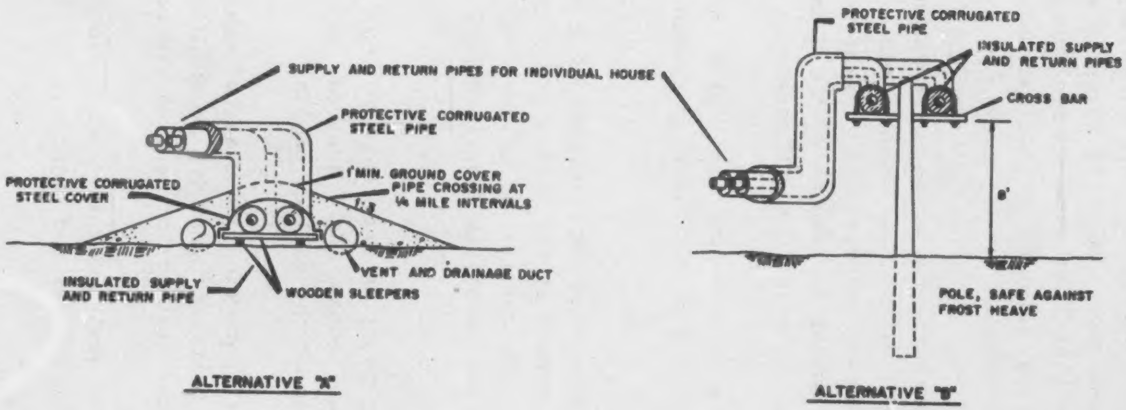

POWERLINE SUPPLYING
MINE AND PLANT
3%
3%
1 : 3
1 : 3
PROTECTIVE
CORRUGATED
STEEL COVER
GRAVEL CROSSINGS Per 1/4 MILE
1' MIN. COVER
WOODEN SLEEPERS
VENT AND DRAINAGE DUCTS
MINIMUM 5' DEPTH GRAVEL
OR THERMAL EQUIVALENT
ORIGINAL GROUND SURFACE LEFT UNDISTURBED

arctic slope
technical services
incorporated

WAINWRIGHT COAL STUDY
MINEMOUTH COMPLEX
ROAD AND MAINS

PREPARED BY: M. S. JOB NO
DRAWN BY: Re SCALE 1" = 10'
CHECKED BY: DATE : 2-17-82

SHEET 12.9


SUPPLY AND RETURN PIPES FOR INDIVIDUAL HOUSE
PROTECTIVE CORRUGATED STEEL PIPE
1' MIN. GROUND COVER
PIPE CROSSING AT 1/4 MILE INTERVALS
1:3
PROTECTIVE CORRUGATED STEEL COVER
VENT AND DRAINAGE DUCT
INSULATED SUPPLY AND RETURN PIPE
WOODEN SLEEPERS
ALTERNATIVE "A"
PROTECTIVE CORRUGATED STEEL PIPE
INSULATED SUPPLY AND RETURN PIPES
CROSS BAR
8'
POLE, SAFE AGAINST FROST HEAVE
ALTERNATIVE "B"

WAINWRIGHT COAL STUDY
MINEMOUTH COMPLEX
ALTERNATIVE PIPE CONFIGURATIONS
PREPARED BY: [illegible]
JOB NO.
DRAWN BY: [illegible]
SCALE [illegible]
CHECKED BY:
DATE: [illegible]

SHEET 12.10

13.0 PHASING

It is our understanding from Mr. Ralph Anderson, Special Assistant to the Mayor, that the Mayor is anxious to pursue the Wainwright Coal Development Scheme in order to obtain a lasting solution in mitigation of the present high cost of energy in the village.

From very recent reports it is now apparent, that speedy and appropriate action has been taken by the NSB and Alaska congressmen and senators to ensure passage of a congressional waiver in respect of the NPRA, which is the single serious obstacle to a comprehensive development.

Accordingly we recommend, that mine development and development of a district heating system be undertaken concurrently.

However, in order that implications of a phased development may be assessed if the need arises, the schedule and the table showing capital costs have been divided into three development phases as described hereunder.

Phase 1: Interim production and usage of coal for heating of individual homes, if desired by a reasonable proportion of the village people.

Phase 2: Long term production and usage of coal incorporating Central District Heating using lowpressure coal-fired water heaters for heating the heating fluid.

Existing Diesel generators will continue to be used for electric power and lighting.

Phase 3: Diesel generators to be supplanted by Organic Rankine Cycle Generators using coal-fired low-pressure water as energy source, or by intertie from Barrow, or supplemented by wind-power

13.01 Phase 1

Phase 1 would be made up of the following components:

- Incline entry
- Exhaust shaft
- Initial section of mine heading
- Underground mining equipment
- Support equipment, underground
- Support equipment, surface
- Covered passage to bulk storage
- Bulk storage building including covered offloading zone
- Service section of minemonth complex including heated bays for diesel equipment and diesel drum storage
- Access road capable of supporting transport of bagged coal to village
- Electrical transmission line
- Additional diesel generating capacity at existing diesel generating station (for heaters and fans in mines)
- Installation of coal-burning stoves or furnaces for interim use and later back-up in individual homes
- Implementation of retrofit energy conservation measures.

13.02 **Phase 2**

Phase 2 would comprise:

- Boiler house and equipmemnt
- Central District Heating System including house installation
- Conversion of mine heater from electricity to heating fluid heating.

Phase 2 could be subphased if desired so as to complete main distribution lines, house connections and house installation in two subphases.

13.03 **Phase 3**

Phase 3 would provide for introduction of Organic Rankine Cycle Generators to supplant Diesel generation for electrical power and lighting.

If the 300 KW pilot ORC generator being funded by Alaska Power Authority can be attracted to Wainwright, Phase 3 could in part be brought forward to coincide with Phase 2.

Alternatively, power and lighting needs could be supplied by an electrical intertie connecting Barrow, Atkasook, and Wainwright, or diesel consumption could be reduced by the installation of wind generators.

14.0 SCHEDULE

Figure 14.1 is a schedule drawn up to show what would be the earliest possible on-line dates, if concurrent development takes place.

On the assumption that green light is given for further work by February 1, 1982, and that all permits including congressional waiver for "commercial" use of NPR-A coal are secured by February 1, 1983, the earliest date for interim coal production would be February 1, 1984.

The earliest house connections under the long term plan could take place midway through 1985, and house connections could be completed during 1986.

The earliest installation and operation of a pilot ORC-generator would be the fourth quarter of 1984.

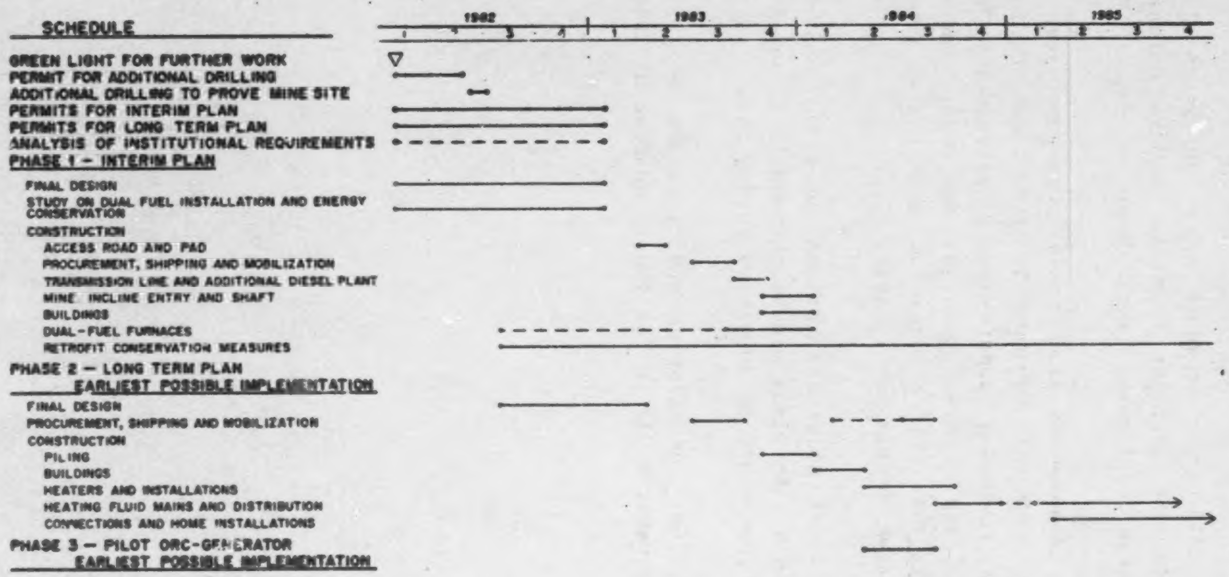

SCHEDULE
1982
1983
1984
1985
1
2
3
4
GREEN LIGHT FOR FURTHER WORK
PERMIT FOR ADDITIONAL DRILLING
ADDITIONAL DRILLING TO PROVE MINE SITE
PERMITS FOR INTERIM PLAN
PERMITS FOR LONG TERM PLAN
ANALYSIS OF INSTITUTIONAL REQUIREMENTS
PHASE 1 – INTERIM PLAN
FINAL DESIGN
STUDY ON DUAL FUEL INSTALLATION AND ENERGY CONSERVATION
CONSTRUCTION
ACCESS ROAD AND PAD
PROCUREMENT, SHIPPING AND MOBILIZATION
TRANSMISSION LINE AND ADDITIONAL DIESEL PLANT
MINE: INCLINE ENTRY AND SHAFT
BUILDINGS
DUAL-FUEL FURNACES
RETROFIT CONSERVATION MEASURES
PHASE 2 – LONG TERM PLAN
EARLIEST POSSIBLE IMPLEMENTATION
FINAL DESIGN
PROCUREMENT, SHIPPING AND MOBILIZATION
CONSTRUCTION
PILING
BUILDINGS
HEATERS AND INSTALLATIONS
HEATING FLUID MAINS AND DISTRIBUTION
CONNECTIONS AND HOME INSTALLATIONS
PHASE 3 – PILOT ORC-GENERATOR
EARLIEST POSSIBLE IMPLEMENTATION

FIGURE 14 1

15.0 CAPITAL EXPENDITURE

Table 15.1 shows capital expenditure for the years 1982 through 1986, based on the schedule shown in section 14.0.

The total cost for mine development (Phase 1) would be $5,970,220.

The total cost for central district heating (Phase 2) would be $7,481,200.

As regards buildings, their cost have in this calculation been estimated at unit prices per sq. ft. actually currently experienced on the North Slope.

TABLE 15.1

CAPITAL COSTS - FEASIBILITY LEVEL ASSESSMENT

NOTE: There is no provision for implementation of
building improvement or dual-fuel installations

PHASE 1

	1982	1983	1984	1985	1986	TOTAL
Mining and support equipment		1,417,500				1,417,500
Preproduction mine development		547,500				547,500
Working Capital			214,000			214,000
Construction management and training program		40,000				40,000
SUBTOTAL		2,005,000	214,000			2,219,000
Access Road and pad 24.000 cu. yds. @ $15		360,000				360,000
Corridor from minemouth to coal storage building 1800 sq.ft. @ $120		100,000	116,000			216,000
Coal handling - storage building (unheated) 6400 sq.ft. @ $160		500,000	524,000			1,024,000
Service and administration building (heated) 6120 sq. ft. @ $200		600,000	624,000			1,224,000
Ocean Transport		280,000				280,000
Transmission line and transformer 5000 ft. @ $15		75,000				75,000
SUBTOTAL		1,915,000	1,264,000			3,179,000
Detailed design, 8%	254,320					254,320
Construction management 10%		191,500	126,400			317,900
TOTAL FOR PHASE 1	254,320	4,111,500	1,604,400			5,970,220

TABLE 15.1 (contined)

PHASE 2

	1982	1983	1984	1985	1986	TOTAL
Boiler building 3840 sq. ft. @ $220		400,000	445,000			845,000
Low pressure water heaters with all supporting systems		900,000	50,000			950,000
Stand-by diesel 150 kw			120,000			120,000
Heating fluid distribution system and supply lines		1,045,000	600,000	1,000,000	380,000	3,025,000
Ocean transport		500,000				500,000
House installations				680,000	220,000	900,000
SUBTOTAL		2,845,000	1,215,000	1,680,000	600,000	6,340,000
Detailed design 8%	257,200	250,000				507,200
Construction man. 10%		284,500	121,500	168,000	60,000	634,000
TOTAL FOR PHASE 2	257,200	3,379,500	1,336,500	1,848,000	660,000	7,481,200
SUMMARY:						
Phase 1	254,320	4,111,500	1,604,400	-	-	5,970,220
Phase 2	257,200	3,379,500	1,336,500	1,848,000	660,000	7,481,200
GRAND TOTAL	511,520	7,491,000	2,940,900	1,848,000	660,000	13,451,420

16.0 RECURRENT COSTS AND RATES

16.01 Electric power and lighting

As regards both the Interim plan and Alternative A-II, Phase 1 and 2, there would be no reason to change present rates on account of the implementation of either one or the other or both, since both plans call for electric power and lighting to be provided by the existing diesel generating station.

16.02 Space heating

16.02.1 General Remarks

It will be recalled that the draft report in the Table 15.1 did not include the Capital Cost of coal storage buildings. In the revised Table 15.1 of this final report the capital costs of buildings have been revised on the bases of unit prices per square foot actually currently experienced on the North Slope.

In relation to Table 4.3.7, page 3-27 of Volume 3 certain revisions will also be made in the following to take account of changes made in the heating of mine ventilation air as compared to what was proposed in volume 3 (electrical heating changed to heating by a loop of the central district heating system).

These revisions have a considerable effect on the estimated cost of coal, most notably for the interim Phase 1, because of the very low production required here.

16.02.2 Revised Estimates of the Unit Cost of Coal

Direct production cost, revised in accordance with proposed changes in heating of ventilation air, and revised capital costs of mine buildings.

Labor (page 3-11, Volume 3) as before $25.84 per ton.

Materials and Supplies	Dollar Per Ton
Fuel: $\frac{8{,}000 \text{ gal. X } \$2.15}{10{,}000}$	1.72
Power:	
Dintheader: $\frac{120 \text{ kw X } \$0.25}{4 \text{ tons x } 60 \text{ minutes}}$	0.13
Main Fan:	
$\frac{80 \text{ X } 24 \text{ hrs X } 55 \text{ kw X } \$0.25}{10{,}000 \text{ tons}}$	2.65
Auxilliary fan:	
$\frac{285 \text{ X } 24 \text{ hrs X } 18.4 \text{ kw } \$0.25}{10{,}000}$	3.15
Heating of ventilation air by district heating:	
$\frac{1.5 \text{ mill BTU X } \$22.65 \text{ X } 80 \text{ X } 24 \text{ hrs}}{10{,}000}$	6.52
All others as before	13.80
Total for materials and supplies-	$27.97

Assessment (page 3-11, vol. 3) as before $8.65 per ton

Depreciation (refer to page 3-29 Volume 3)		Phase 1 2200 tons per annum $ per ton	Phase 2 4000 tons per annum $ per ton
5 years life	$ 20,000	$ 1.80	$ 1.00
10 years life	$ 218,000	9.90	5.50
20 years life	$5,732,220	130.20	71.60
		$141.90	$78.20
1/2 (50 0/0 GRANT)		70.95	39.10

Financial charges:
(Refer to page 3-30, vol. 3)
Total interest on capital cost of $5,970,000

$$\frac{955{,}000 \times 5{,}970{,}000}{1{,}842{,}000} = \quad \$3{,}095{,}195$$

		Charges per ton
Phase 1:	20 years production 44,000 tons	$70.35
Phase 2:	20 years production 80,000 tons	$38.69

Summary of production costs:
(Refer to page 3-11, vol. 3)

	Phase 1 2,200 tons per annum $ per ton	Phase 2 4,000 tons per annum $ per ton
Labor	$ 25.84	$ 25.84
Material and supplies	27.97	27.97
Assessments	8.65	8.65
Depreciation	70.95	39.10
Financial charge	70.35	38.69
	$203.76	$140.25

If all homes were to switch to dual-fuel space heating - 167 homes forecast by 1982 - the consumption of coal would be around 2200 tons per annum. At this level of production, the coal would cost $203.76 per ton to produce.

The individual home of 960 sq. ft. would have an average peak requirement of 24,000 BTU per hour. At an efficiency level of 50% for dual-fuel furnaces, this would translate into:

$$\frac{24{,}000 \times 4422}{8{,}800 \times 2000 \times 0.5} = 12 \text{ tons/annum}$$

At a cost of 12 x $203.76 = $2,445 per annum for an average household.

The cost of heating the same house to the same level of comfort by fuel oil with a heating value of 130,000 BTU/gal. would be:

$$\frac{24{,}000 \times 4422}{130{,}000 \times 0.6} \times \$2.15 = \$2{,}700 \text{ per annum}$$

The revised unit cost of coal rules out Phase 1 as a viable interim plan, even if all homeowners could be persuaded to join. If only half would join, the cost per ton would be:

	$ per ton
Labor	$ 25.84
Materials and supplies	27.97
Assessments	8.65
Depreciation	141.90
Financial charges	140.70
TOTAL	$345.00

This indicates the sensitivity of the plan to lack of interest on the part of homeowners.

It is therefore obvious, that Phase 1 cannot stand on its own and should only be undertaken concurrently with Phase 2.

16.02.4 Alternative A-11

Taking account of the revised unit cost of coal and the revised table of capital costs, the recurrent cost for the mine, the minemouth complex and the central district heating system would be as follows:

Capital costs of Phase 2: $7,481,200

Interest:

	Recurrent cost per annum
8 0/0 on 1/2 capital cost	$ 299,248
Retirement of capital 25 years, 4%	299,248
Labor	160,000
Coal 3947 X $140.25	553,570
Maintenance and spares	40,000
	$1,352,068

At a total annual consumption of 60 billion BTU, the above annual recurrent costs (1981 dollars) work out at:

$$\frac{\$1,352,068}{60,000} = \$22.53 \text{ per mill. btu}$$

The cost of heating the average home under alternative A-II would therefore be:

$$\frac{24,000 \text{ X } 4420}{1,000,000} \times \$22.53 = \$2390 \text{ per annum}$$

17.0 SOURCES OF LOCAL MATERIALS

There are two local materials, the absence of which would have serious implications for the project. They are water for the initial filling of the district heating system - and gravel for the access road and pad.

17.01 Water

The quantity of water required for the initial filling of the district heating system amounts to 30,000 - 40,000 gallons. this is a fairly small quantity in relation to the 2 million gallon storage capacity in the village. The provision of this water from the village supply plant should present no great difficulty, if delivered in the summer, when the storage tanks have been filled.

Analysis of water from the fresh water lake and from the central water facility are shown in table 17.1.

This water analysis are conducted by the State of Alaska, Department of Environmental Conservation, Douglas Laboratory Facility. The analysis is part of the Village Safe Water Program and parameters analysed are guidelines for good quality of drinking water to protect your health.

For industrial usage there is no need to analyse the water from a health point of view, but since water is acceptable for drinking purposes it also is generally adequate for industrial use. However, some of the chemical parameters, like iron, are high and can cause deposits to settle in the distribution system. To get rid of high levels of chemicals there is a need for extra storage time to let them settle or to add some chemical agents to help the settling. To find out if it is justified to build a storage/settling basin more water samples have to be analysed.

TABLE 17.1
WAINWRIGHT, WATER ANALYSIS

Analysis	Limit	Fresh water lake water source, 5/3/79, mg/l	Central Water facility, tap water, 5/3/79, mg/l
Arsenic	0.05	ND	ND
Barium	1.00	0.10	ND
Cadmium	0.010	TR	TR
Chromium	0.05	ND	ND
Iron	0.3	0.67	0.3
Lead	0.05	0.006	TR
Manganese	0.05	0.007	0.008
Mercury	0.002	ND	TR
Selenium	0.01	ND	ND
Silver	0.05	ND	ND
Sodium	250	94	10.6
Calcium	-	27	3.0
Magnesium	-	-	-
Potassium	-	-	-
Chloride	-	250	31
Fluoride	2.40	TR	ND
Nitrate -N-	10.00	1.5	TR
Sulfate	-	TR	TR
Carbonate Alkalinity	-	70	7.0
TFR	-	407	47
ph	-	7.3	6.0
Turbidity	-	2.4	1.6 (NTU)
Color	-	50	10.0 (PCU)
Conductivity	-	620	81 (micromhos/cm)

ND = Not detected

TR = Trace detected

17.02 Gravel

There will be a need of 25,000 - 40,000 cu. yds. of gravel for access road and pad, subject to material from the incline excavation being suitable for stable fill.

The consultant is informed, that the NSB propose to dredge and stockpile 600,000 cu. yds. of gravel near a lagoon on the Kuk Inlet about 8 miles South of Wainwright.

By letter the consultant advised the NSB that sufficient gravel for this project be reserved for delivery from the proposed stockpile.

18.0 SERIOUS OBSTACLES TO PROJECT DEVELOPMENT

During the course of this study a few serious obstacles to project development have been identified. They are:

18.01 BLM Coal Lease

Section 5.4.1.1 (A) (1) (a), page 5-6 of Volume 1 refers. A lease for "commercial" purposes requires a congressional waiver. Timely and appropriate action is being taken at this time by the NSB, Congressman Young and Senator Murkowski to overcome this obstacle.

18.02 Jurisdiction of the Office of Surface Mining

There are conflicting opinions, also within the OSM itself, as to whether the OSM has jurisdiction in the present project.

If the OSM were to claim jurisdiction, this would prolong the permitting time-span. This has been taken into account in the Schedule, Section 14.0.

18.03 Underground Mining by Village People

The question as to whether village people will work mining machinery underground is perceived as a possible serious obstacle by Kent Grinage, former Director of Utilities, NSB.

More will be known about this following the Public Awareness Program included in the proposal for further work.

Other than the above, no serious obstacles to project development is perceived by the consultants.

19.0 REVIEW COMMENT BY THE NORTH SLOPE BOROUGH AND RESPONSE

19.01 Memorandum to the Mayor from Kent Grinage, former Utility Manager, dated December 30, 1981.

1. Comment:

Will people work in an underground tunnel? We cannot find anyone willing to climb the power poles in the villages even though the villages want electricity. This same situation may apply. This should be investigated thoroughly.

Response:

On putting this question at the Public Hearing in Wainwright held on January 26, 1981, no real indication was obtained. One councillor stated: "We don't know what an underground mine is."

It is recognized by the consultants, that this is a serious concern. In order to obtain a reasonably reliable reply to this question, the consultants feel, that a special Public Awareness Program is required in order to impact to the village people a visual understanding of the project and the concept of an underground mine. The scope of such a program will be contained in a proposal to be forwarded to the NSB dealing with further preconstruction work.

2. Comment:

Underground mining comes under stringent safety and training requirements as set down by the Mining Safety and Health Administration.

Response:

MSHA Training requirements exist for surface mines as well. Required training 40 hours underground, 25 hours surface, etc. Both are complicated. Underground may be slightly more involved.

3. Comment:

Underground mining will require outside supervision.

Response:

Both surface and underground will require outside supervision initially.

4. Comment:

Underground mining will require specialty parts and high level of technical expertise to maintain the special equipment such as the Dosco Dintheader excavator.

Response:

Both will require specialty parts and training, especially maintenance. Underground may be easier because of less pieces and types of equipment and less exposure to winter conditions.

5. Comment:

The underground mining will require design and continuous maintenance to maintain the integrety of the mine.

Response:

Both mines will require design and maintenance, permit compliance, etc. It may be easier unerground (less material moved, uniform conditions, etc.).

6. Comment:

The shaft alone will change the thermal balance in the permafrost. ASTS proposes to add additional heat with two air heaters. This may cause subsidence and erosion.

Response:

Both underground and surface mines will thaw material and change thermal balance. Shaft exposes less area than pit. Heaters are not to heat air significantly (only to acceptable working temperature). Mine will still remain frozen at all times; estimate 20°F working temperature.

7. Comment:

The shaft may collect water which could be pumped but this presents an additional maintenance requirements.

Response:

Shaft may collect minimal water. Should be less of a problem than a pit, especially in summer. Pit will require pumps; probably more.

8. Comment:

The shaft may have to be ventilated year round to ensure methane gas does not collect in sufficient quantities to create a potential hazard. If so this will be an additional maintenance and operation cost.

Response:

It is planned that ventilation would be year-round; minor maintenance.

9. Comment:

ASTS proposes to use the following mining equipment that operates on electricity.

a. Two air heaters 305 kW per unit.

b. Dosco Dintheader Excavator. No kW load in report.

c. Exhaust fan 40,000 CFM. No kW load in report.

The two air heater fans totaling 610 kW far exceeds the peak load of the entire village power plant. A detail analysis of the load requirements for the entire operation should be done. This problem is not identified in the report but presents a major problem.

Response:

The mine report was prepared as a basis for the final evaluation as to whether or not coal-fired steam generation should take place. If this had been the choice, the generating plant would be designed with capability to supply the mines' power needs.

The draft report in Volume 1, Section 12.07, page 12-6 and 12-7 proposes, that the electrical energy load for the mine will be reduced by about 80% by heating the ventilation air by means of a loop from the district heating system.

The final report will further propose, that intermediate heating of the ventilation air will take place by oil-fired space heaters instead of by electricity as originally proposed.

When the mine is operating, the dintheader with a total load of 120 HP would operate in short bursts and the main fan of 75 HP would be in constant use. During non-mining periods only the auxiliary fan of 25 HP would be operating.

If these loads were to constitute a problem in periods of peak village demand, the more-complex standby diesel generator could help out.

In these circumstances we do not see any major impact in relation to the village power supply.

10. Comment:

The recommended mine location is the one closest to the village, 1/2 mile northeast of Wainwright. There may be a problem of dust coming out in the village and/or kids going in from the village. Security and safety should be a prime concern to the community.

Response:

The advantage of the underground mine is that it is close to the village. Much less dust will be generated underground than from a surface mine. It is much easier to secure a portal (would already have doors for temperature control) than a pit. Pit equipment would be more accessible and dangerous.

11. Comment:

The proposed wages for the mine operation would not attract anyone to the job.

Response:

The proposed wages in the report (after applying Alaska multiplier) are $180 per day, or $24± per hour, for the 80 operating days per year. If these wages are low for underground, they would also be low for surface and relative cost conclusions are still the same - underground is cheaper.

Closing Remarks.

Comment:

It is my opinion more thought should go into an underground mining operation. The operation should maximize local hire, be low in maintenance, and as safe as possible. I would recommend further work be done on locating a shallower coal deposit so a surface mine could be utilized.

Response:

This consultant started off with the idea, that a surface mine would be the natural choice.

As facts emerged during the course of the study, it became more and more clear, that underground mining had superior merits. Very careful thought has gone into our recommendation. There is nothing in the above comments that have changed our mind.

Nevertheless, we would naturally willingly undertake any additional studies that the Borough may require if it is deemed to throw further light on this issue.

Apart from the technical, environmental and economical merits of the underground mine, having regard to possible future coal developments elsewhere in the Borough, we consider the Wainwright underground mine concept to be exciting from the point of view of forming a counterpart to the Atkasook surface mine, which could provide a valuable basis for comparison and an experience base for future development.

19.02 Preliminary Review Comments from Department of Public Works, Undated

1. Comment:

Whether local labor is interested in and willing to work this mine should be first examined. This should have been the first issue to be examined in this feasibility study. Can the local force be adequately trained?

Response:

See response to Item I1 and I2 above.

2. Comment:

All required permits and authorization should be identified in a feasibility study of this kind not just those relating to the environment.

Response:

The original contract entered into between ASTS and the North Slope Borough on December 22, 1980 recited the following: "...ASTS will conduct a study designed to determine what environmental permits and licenses will be required for implementation of the Wainwright District Heating and Power Generation Project" (p. B-2, emphasis ours). As we noted in the feasiblity study:

> We are aware that various additional authorizations may be required (e.g., a Water Rights Permit from the Alaska Department of Natural Resources, a Public Utilities Commission, and various State building approvals and requirements); however, the discussion of such authorizations is beyond the scope of this report in that they are not expressly environmental in nature. Nevertheless, of all the authorization required, it is those discussed in this section (i.e., Chapter 5.0) that will demand the bulk of the Borough's time and energies to obtain. (Section 5.1, p.5-1.)

3. Comment:

All factors affecting feasibility of mine operation should be identified and examined. Items of major concern such as sources of water for mine operation and sources of gravel for mine construction should be thoroughly covered in this study.

Response:

The consultants believe, that they have fairly examined and identified all factors affecting the feasibility of the mine operation.

The question of water and gravel have been addressed in Section 17.0 of the final report.

4. Comment:

Potential conflicts with federal and state regulations should be identified and examined in a section of the study dedicated to "Serious Obstacles to Project Development."

Response:

The only potential with federal or state regulations that the Wainwright project would pose is described on p. 5-6 (Section 5.4.1.1.(A)(1)(a)) of the feasibility study:

> The Full Scale Development Option cannot be implemented without a (U.S.) BLM Coal Lease...the specific regulations for which are contained in 43 CFR 3420 and 43 CFR 3422. However, under

> present law and regulations, the BLM is not authorized to issue coal leases within the NPR-A (National Petroleum Reserve Production Act of 1976 (P.L. 944-258); 43 CFR 3400.2(a)(7))...Nevertheless, a movement is currently afoot to open the NPR-A to coal leasing. In the latter part of 1980...the NPR-A was opened to petroleum leasing (Gal 1981). In July, 1981, U.S. Senator Frank Murkowski wrote then-North Slope Borough Mayor Jacob Adams that he was investigating allowing the Borough to mine coal within the NPRA-A...

Within an hour of this writing, Senator Murkowski is expected to introduce such legislation before a U.S. Senate committee, with a hearing expected on the bill in a couple of weeks. An analogous piece of legislation was just introduced by Congressman Young before a U.S. House of Representative committee. Both bills deserve close watching in the weeks ahead; once they are passed, no major legal obstacles to the project should remain.

5. Comment:

Exact home heating requirements as to the amount of coal required should be specified:

Response:

They are specified in Section 8.05.3.2 on page 8-16 of the draft report (page 8-16 of the final report).

6. Comment:

Expenditures listed based upon lower 48 mining operations are unrealistically low. These costs should have been estimated by research not by using multipliers to equate them with lower 48 figures.

Response:

The costing procedure used for this preliminary study was to cost the operation by lower 48 procedures and multiply capital costs by 1.5 and operating costs by 2.0. It is felt that this procedures is acceptable for the accuracy of a feasibility study. Even if the multiplier is wrong, it will still be consistent for each type of mine, so that recommendations of surface mine versus underground mine are still pertinent.

The multipliers were based on what little literature information is available, on what costs could be documented, and from research done during the recent gravel study. For instance:

1. Lower 48 fuel costs approximate $1.00 to $1.15 per gallon. Wainwright fuel costs are in excess of $2.00 per gallon, or a 2.0 multiplier.

2. Labor costs for lower 48 mines are in the range of $10 to $12 per hour. Wainwright was estimated to be $20 to $25 per hour, or a multiplier of 2.0.

3. The need to train personnel was accounted for by increasing the amount of labor (i.e., cost).

There are not any similar operations on the North Slope, surface or underground, that can be used for cost comparisons. Any system used to develop costs cannot be documented adequately at this time, and the factoring approach is felt to be reasonable until a specific mine size and type are selected. At the time that a detailed mine plan is developed for submittal to regulatory agencies, capital cost can be estimated from quotations and freight rates, but operating costs will still be a "best guess" until actual on-site experience is developed.

7. Comment:

Sources of project funding appear unrealistically optimistic. What sources will provide a 50% grant? What sources will acquire bonds at 8% interest?

Response:

The basis for project funding sources was supplied by the NSB (Kent Grinage). In view of current trends this basis should indeed be reviewed.

8. Comment:

The cost consideration for a surface mine in area A-B should have been examined before eliminating surface mining as a viable option.

Response:

A surface mine was not costed for area A-B due to the depths of overburden, and proximity to the village. The costs were generated for the area C (best case) surface mine. An area A-B surface mine would be substantially more expensive - reinforcing the existing recommendation of underground mining. (See also Item I10.)

9. Comment:

Sections 14.0 and 15.0 of Volume I should be further broken down to show the scheduling and capital expenditures for phases 1 and 2 separately. Assuming that both phases would be persued simultaneously was highly optimistic.

Response:

Sections 14.0 and 15.0 will be broken down as suggested in the final report.

We have expressed ourselves ambiguously. The schedule seeks to illustrate the fastest practicable development, which of course predicates the assumption that Phase 1 and 2 will be pursued simultaneously.

20.0 RECOMMENDATIONS AS TO FURTHER WORK

20.01 If it is the NSB's decision, that work should proceed towards the early and most economical implementation of the interim coal supply plan, the following additional work should be considered.

20.01.0 Implement a public awareness program, including:

- o Presentation to the public of a cut-away model showing the underground mine, the heating plant and the village with the distribution pipes installed.
- o Presentation of slides and/or a movie showing underground mining.
- o A probable visit by some people from Wainwright to an underground coal mine.

20.01.2 Additional drilling to confirm specific mine location as recommended in Section 3.01.2.8, Volume 2.

20.01.3. Soil investigations for the foundations of the plant.

20.01.4 Environmental Studies as recommended in Section 5.6, volume 1.

20.01.5 Submission of detailed underground mine plan to the Mine Safety and Health Administration as recommended in Section 3.01.2.9, Volume 2.

20.01.6 Submission of applications to all agencies concerned as detailed in Section 5.0, Volume 1 (interim supply plan - Phase 1).

20.01.7 Analysis of institutional requirements in connection with the interim coal supply plan.

20.01.8 Investigation of costs and benefits of building improvements and other basic energy conservation measures, in the village.

20.01.9 Planning of dual-fuel installations on a village - wide scale, compatible with the long term plan.

20.01.10 Final design and specifications relating to the following components:

- Mine and mine installations.
- Covered passage, bulk storage building including off-loading area.
- Equipment for mine and storage building.
- Provision for bagging and transporting coal to Wainwright.
- Service building.
- Access road and pad.
- Transmission line.

- Additional diesel generating plant to increase capacity of existing diesel generating station.
- Firming up of costs for Phase 2 buildings and installations.

20.02 If the NSB is desirous of pursuing the long term plan simultaneously with the interim plan, the following additional work should be considered.

20.02.1 Submission of applications to all agencies concerned as detailed in Section 5.0 (long term plan - phase 2). There may be some economy in undertaking items 20.01.6 and 20.02.1 simultaneously.

20.02.2 Analysis of institutional requirements in connection with the long term heating plan.

20.02.3 Updating impact of recent town-planning considerations on distribution network for heating medium (relocation of airstrip).

20.02.4 Final design and specifications relating to the following components:

- Boiler room building.
- Coal-handling equipment and bunker.
- Low-pressure water heaters.
- Ash handling system.

- Cyclones and stack.
- Supporting systems in boiler room.
- Heating fluid distribution system including circulation pumps and pressure vessel.
- Supply lines and house installations.

20.03 If there is not sufficient village support for an interim coal supply scheme, and the NSB is desirous to implement the long term plan as the first and only priority, the items enumerated under sections 20.01 and section 20.02 would all be called for, with the exception of items:

20.01.6
20.01.7
20.01.9

CENTRAL DISTRICT HEATING AND POWER GENERATION PROJECT

Prepared for

NORTH SLOPE BOROUGH

VOLUME 2

EXPLORATORY DRILLING PROGRAM

Prepared by

Arctic Slope Technical Services, Inc.
420 L Street, Suite 406
Anchorage, Alaska 99501

February 1982

3.0 INTRODUCTION

This report describes the work performed and the results obtained in Tasks 1 through 4 of the second phase of the Arctic Slope Technical Services' (ASTS) Wainwright Power Generation and District Heating Project.

This work was conducted under the North Slope Borough Department of Public Works contract authorization of November 25, 1980, Purchase Order Number 14035. A purchase order amendment was authorized April 23, 1980 for additional professional and contractor services for the summer exploratory drilling program.

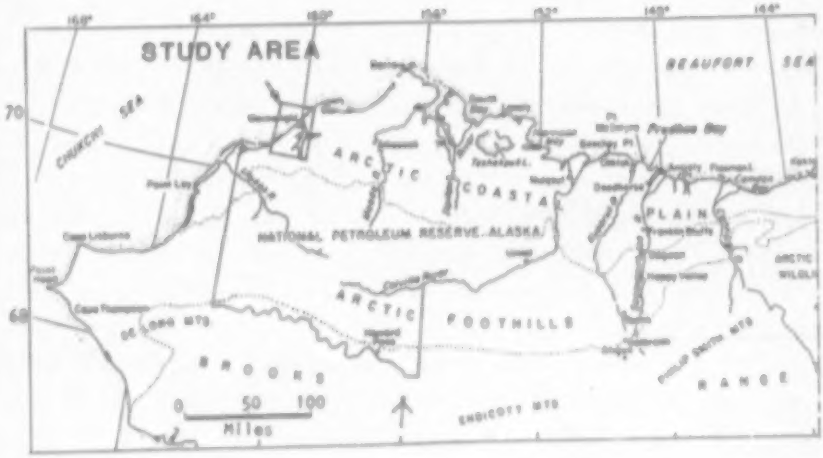
3.1 TASK 1 EXPLORATORY DRILLING PROGRAM/DESIGN AND PERMIT ACQUISITION:

General

The purpose of the exploratory drilling program was to gather quantitative information on the distribution, quality, and thickness of the coal seams in the Wainwright area, and to determine the depth of the overburden in the areas of potential mining and power generation sites near the Village of Wainwright (Figure 3-1). The program was preliminary, in that the data gained will be utilized to determine if additional predevelopment geological and geotechnical information is required for an orderly and cost-effective development of the Wainwright Power Generation and District Heating Project. The results of the drilling program are discussed in Section 3.4.4. The results of the coal sample quanitative chemical analyses are presented in Section 3.4.6. Recommendations for further geological/geotechnical investigations are presented in Section 5.6. Prior to the initiation of field drilling, a drilling program was planned and the necessary exploration permits were obtained.

3.1.1 Design of Exploratory Drilling Program

The design, methodology, and scheduling of the exploratory drilling program was completed by Ertec Northwest and Ertec Rocky Mountain geotechnic and mining personnel during January 1981. Geological literature, maps, and aerial photography of the previous investigations of the coal resources in the Wainwright area were collected from federal, state, municipal, and private sources. Reports and papers on the

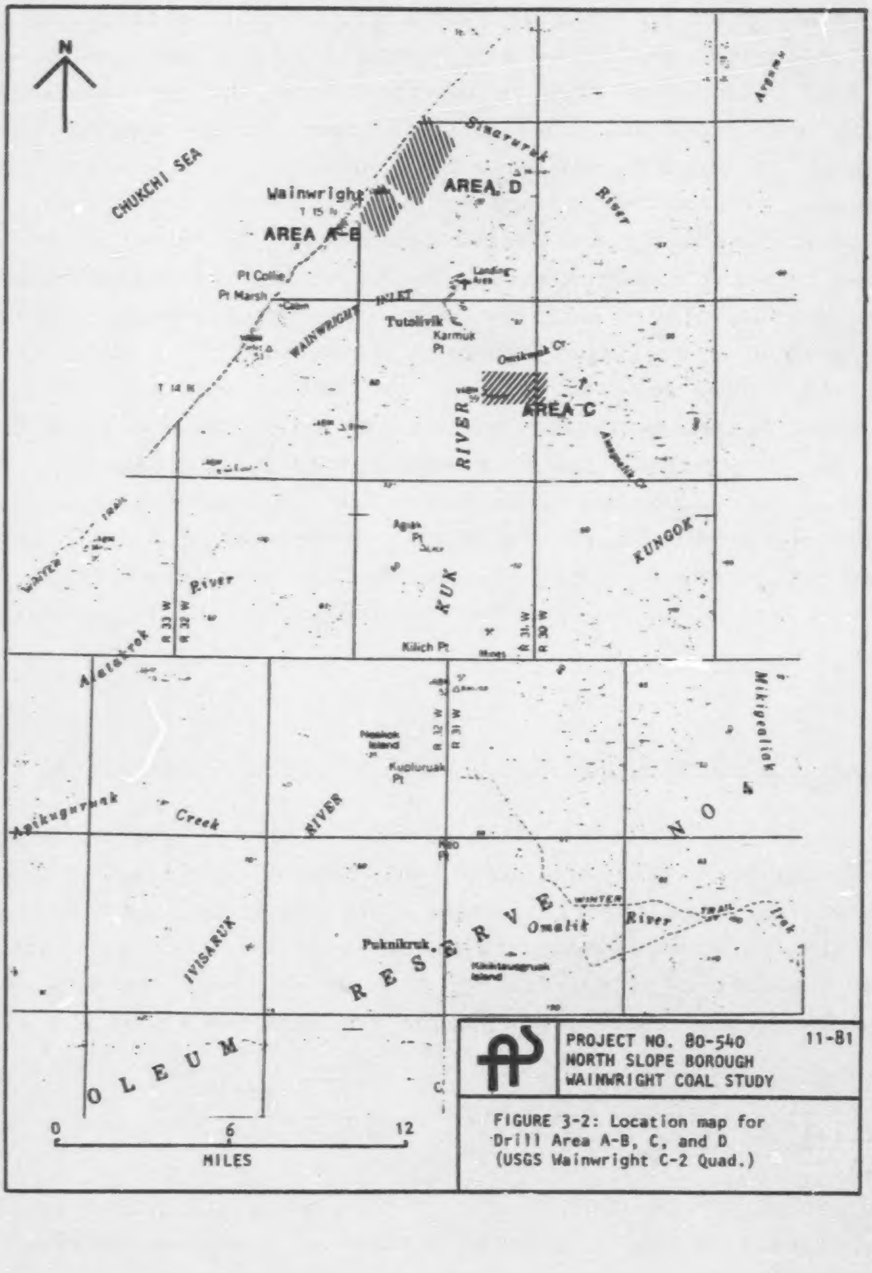

168°
164°
160°
156°
152°
148°
144°
STUDY AREA
70
68
CHUKCHI SEA
BEAUFORT SEA
Barrow
Prudhoe Bay
Beechey Pt
Teshekpuk
Deadhorse
Point Lay
Cape Lisburne
Cape Thompson
ARCTIC COASTAL PLAIN
NATIONAL PETROLEUM RESERVE, ALASKA
Franklin Bluffs
Sagwon
Happy Valley
ARCTIC WILDL
Colville River
ARCTIC FOOTHILLS
DE LONG MTS
BROOKS RANGE
PHILIP SMITH MTS
ENDICOTT MTS
0
50
100
Miles

PROJECT NO. 8C-540 . 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-1 : Overview and physiographic province map of northern Alaska (After: Wahrhaftig 1965)

general geological conditions of the area were also collected. Subsurface geological and coal quality information was obtained from the United States Geological Survey (USGS) (draft) open-file report on Preliminary Results on the Coal Stratigraphy and Resources of the Nanushuk Group from Shallow Geophysical Logging Program in the Wainwright Inlet-Beard Bay Area, northern Alaska (Martin 1980).

Based on data from Martin (1980) on projected coal subcrops, probable depth and thicknesses of coal seams, and the proximity to the village, four drill areas were selected. The proximity to the village was important for mining engineering power plant and environmental considerations. The four primary exploratory drill areas, A, B, C, and D, are shown in Figure 3-2. Approximately twenty primary borehole locations were selected and patterned on approximate half-mile centers. Alternate borehole locations were selected on quarter-mile centers to allow adjustment of the drilling patterns based on the actual subsurface coal intercepts as determined in the field. At the time of the exploratory drilling program design, it was determined that NX (2.5 in. diameter) core or equivalent would be required to provide a sample size of sufficient diameter for the coal quality analysis. It was also determined that the following geophysical logs would be conducted to supplement the coal data evaluation: 1) natural gamma; 2) gamma-gamma, high resolution density; and 3) caliper. These supplemental geophysical logs would be used to confirm depth, thickness and coal seam intercept information if subsurface conditions (i.e. permafrost, fractures, bedding) resulted in poor core recovery.


N
CHUKCHI SEA
Wainwright
T 15 N
AREA A-B
AREA D
Sinaruruk
River
Pt Collie
Pt Marsh
Cabin
WAINWRIGHT INLET
Landing Area
Tutolivik
Karmuk Pt
Omikmak Cr
RIVER
AREA C
T 14 N
Agiak Pt
KUK
KUNGOK
River
R 33 W
R 32 W
R 31 W
R 30 W
Kilich Pt
Alataktok
Mikigealiak
R 32 W
R 31 W
Nasikok Island
Kugluruak Pt
Avikugurruak
Creek
RIVER
N O
IVISARUK
R E S E R V E
WINTER TRAIL
Omalik
River
Puknikruk
Kikiktaugruak Island
O L E U M
0
6
12
MILES

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

11-B1

FIGURE 3-2: Location map for Drill Area A-B, C, and D (USGS Wainwright C-2 Quad.)

After selection of the primary and alternate borehole sites by the geological staff, an environmental review was undertaken by ASTS personnel. This review considered the borehole locations and potential core drillin operational impacts with respect to significant waterfowl habitats, anadromous fish streams, caribou calving and fox denning areas, threatened and endangered wildlife and vegetation species and description of known cultural resource sites, including both traditional land use and subsistence activity areas. The environmental review was conducted utilizing federal, state, municipal (NSB), and private references and maps of the Wainwright area and the National Petroleum Reserve-Alaska (NPR-A). The environmental review determined that the exploratory drill areas (A, B, C, D) and borehole sites were not located in areas of critical, sensitive, or significant environmental and cultural resource concern. This allowed for orderly acquisition of federal and state permits for the exploratory drilling operation.

3.1.2 Permit Acquisition for Exploratory Drilling Program

By use of the State of Alaska Permit Directory and telephone conversations with both state and federal agencies, it was determined that federal, state, and municipal permits and letters of permission/non-objection were required to conduct the exploratory core drling program. These permits and letters of permission/nonobjection are outlined below.

Federal

- Temporary Use Permit (TUP) - This permit is issued by the Bureau of Land Management - National Petroleum Reserve-

Alaska (BLM-NPRA) project office in Fairbanks, Alaska. This permit required legal and technical information regarding the nature of the proposed exploratory drilling operation, borehole locations, proposed schedule, manpower and equipment requirements, and maps showing the areas for temporary land use.

The BLM-NPR-A Temporary Use Permit was initially applied for in December of 1980 for a proposed winter, overland, tracked vehicle, air-rotary drilling program. After an evaluation of cost, logistical, and technical factors concerning the proposed winter operation, Arctic Slope Technical Services (ASTS) in conjunction with the Department of Public Works (DPW)-North Slope Borough representative, recommended a change in schedule in order to conduct a summer, helicopter supported exploratory core drilling program. In March 1981, a TUP amendment/updated operational plan was sent to the BLM-NPR-A office. The BLM-NPR-A then conducted an in-house Environmental Assessment regarding the drilling operation and environmental, archeological, and Native allotment concerns within the Wainwright area. The TUP was approved and officially authorized on May 14, 1981.

o Environmental Protection Agency (EPA) (Region X, Seattle, Washington) - The EPA was contacted regarding the use of dilute methanol-water drilling fluids, tundra disposal of the fluid, toxicity, and the potutial for surface water contamination during drilling. The EPA responded with a "letter of non-objection" due to the dilute methanol concentrations involved, the relatively small fluid volumes and mixing and evaporative effects of the methanol with seasonal surface waters. The Alaska Department of Natural Resources and Department of Environmental Conservation were also informed of methanol disposal during drilling program.

- The Bureau of Indian Affairs (BIA) - The BIA was contacted with regard to the location of the exploratory boreholes and surface activities in relation to Native land allotments. The environmental assessment, conducted by the BLM-NPR-A project office, indicated the presence of two Native allotments on lands adjacent to the proposed exploratory drill areas. The Native allottment holders were Mr. Warner Asogeak (File No. 14342B) and Mr. Byrd Kayutuk (File No. F-16266). Letters of information detailing the goals of the overall Wainwright Power Generation and District Heating Project and plans for exploratory drilling were sent to the above mentioned allotment holders. Copies of the letters were also sent to the NSB, BLM-NPR-A and BIA. Since the exploratory drilling operation did not affect the allotted lands, no further action was required.

State of Alaska

- Department of Natural Resources - Division of Forests, Land and Water Management (AKDNR-DFL & WM), Fairbanks, Alaska. The department was contacted for a temporary water use permit for the surface acquisition of approximately 24,000 gallons of water for use as drilling fluid. The Alaska DNR-DFL & WM manages all waters (rights, acquisition and temporary use) within the state of Alaska, including waters within the boundaries of federal lands, such as the NPR-A. Arctic Slope Technical

Services, Inc. applied for the temporary use and surface source (thaw lakes, ponds, etc.) acquisition of 24,000 gallons of water in March of 1981. The temporary water use permit (TWUP) was issued May 1981 and valid for the exploratory drill program schedule of July 1 through August 14, 1981.

- Alaska Department of Environmental Conservation (DEC), Fairbanks, Alaska was contacted and informed of the proposed exploratory drilling operation, borehole locations, schedule, and use of dilute methanol drilling fluids. No permit was necessary from DEC to conduct the exploratory drill program. The Alaska DEC did respond with a letter of non-objection and stipulations for dilute methanol disposal on the tundra.

- Alaska Department of Fish and Game, Habitat Division, Fairbanks, Alaska - This department was notified both by ASTS and Alaska DNR-DFL & WM regarding the exploratory drilling operation and temporary water use permit (TWUP) application. Since no proposed exploratory activities affected the Kuk River (an anadromous stream) and its tributaries in the drill areas, no Title 16 - Anadromous Fish Act permit was required. A letter of nonobjection was issued June 1981.

- Alaska Department of Transportation - Airport Leasing Division, Fairbanks, Alaska - This department was contacted regarding a lease-type permit to place a 1500-gallon, vinyl fuel storage bladder on the apron at Wainwright village airport. This permit was granted June 12, 1981 with stipulations concerning coordination of bladder placement with the Northern Regions Operations Manager and the requirement for an impermeable liner to prevent fuel spillage on the tundra adjacent to the airport gravel apron.

North Slope Borough-Municipality

- The North Slope Borough (NSB) municipality does not have direct permit requirements for exploratory drilling activities as proposed for the Wainwright Power Generation and District Heating Project. During the permit application process the NSB Department of Public Works, Planning Department, NSB Wainwright Village Coordinator, and NSB attorney were continually informed concerning the status of all permits and agency discussions. An informational meeting was conducted by ASTS at the NSB headquarters, in January, 1981 at Barrow, Alaska, regarding the drilling program and permit process.
- The Olgoonik (Wainwright Village) Corporation was also informed regarding the drilling program, drill-area and borehole locations, and permit status during the application process. An informational meeting was conducted in Wainwright by ASTS in April 1981 with the Wainwright Village City Council, Wainwright NSB personnel, and Olgoonik Corporation members concerning the drilling program, proposed operation, schedule, potential impacts, and permit process. A letter of non-objection from the Olgoonik Corporation was received in February 1981.

3.1.3 Permit and Licensing Analysis for Project Construction and Operation

In conjunction with Task 1.2, exploratory drilling permit acquisition, a detailed analysis of the environmental permits and licenses required for the final project implementation and for the interim use of coal for domestic non-profit purposes was conducted. This analysis, critical path schedule, and references are given in Chapter 5.

3.2 TASK 2 CONTRACTING FOR FIELD DRILLING

In the initial ASTS Wainwright Power Generation and District Heating Proposal of July 1980, ASTS recommended that the NSB directly contract the drilling services and consider it a vehicle for a local, native-owned business venture/opportunity. Based on the technical, administrative and schedule requirements for drill contractor selection, the NSB requested that ASTS directly scope, evaluate, and select the drill contractor to perform the required work for the Wainwright Power Generation and District Heating Project exploratory core drilling program. Based on this request and as contracted under Task 2, ASTS, conducted the following sub-tasks for drill contractor selection.

3.2.1 Preparation of Drill Contract Specifications

The design of the exploration program led to a determination of the performance and equipment specifications which would be necessary to successfully obtain the required geologic information. The initial program consisted if winter, overland, tracked vehicle/drill rig exploration to be conducted during March-April 1981. Drill contract specifications were prepared which included, but were not limited to, the following:

- The type of drill and capabilities, tracked equipment
- The availability of the drill rig
- The drilling method, borehole size, core barrel type
- The method of mobilization-demobilization (overland, airborne)
- The condition of the drill equipment
- Geophysical logging capabilities, equipment, operator experience

- Logistical and remote camp support
- Cost estimate - not to exceed - for twenty borehole program including fixed costs, reimbursible items, inclement weather provisions, mechanical and downtime considerations.

3.2.2 Selection of Qualified Drill Contractors for Bidding

The initial solicitation for bid to conduct the winter, overland drilling program was sent to five potential drill contractors in February 1981. The five contractors were:

- Arctic Slope/Alaska General Inc., Anchorage, Alaska;
- Eskimos Inc., Barrow, Alaska;
- Exploration Supply Company, Inc., Anchorage, Alaska;
- Salisbury and Dietz, Inc., Spokane, Washington; and
- The Drilling Company, Fairbanks, Alaska.

These contractors were selected to receive bids based on their previous experience in similar programs, their familiarity with North Slope climatic and drilling conditions, and on their expressions of interest to ASTS personnel to participate in the Wainwright program. As per the request of the NSB program coordinator, information regarding the NSB Nodwell mounted Acker NMP-4 drill rig and its potential for use on the drilling program included within the bid solicitation.

3.2.3 Selection of Drilling Contractor and Planned Program Modification

Salisbury and Dietz, Inc., Spokane, Washington, and Exploration Supply Co., Inc. (EXSCO), Anchorage responded to the bid request Arctic Slope/Alaska General, Inc., Eskimos, Inc., and The Drilling Company, Inc. declined to respond to the bid solicitation. Bid item evaluation and comparison showed that EXSCO did not plan to supply geophysical equipment of sufficient quality along with an experienced operator to perform geophysical logging as per the standards expected by ASTS technical group. Salisbury and Dietz, Inc. provided geophysical services through Digilog, Inc., a Colorado based coal and uranium downhole logging firm. Equipment and operator experience provided by Digilog, Inc. were of a quality acceptable to ASTS.

The Salisbury and Dietz, Inc., bid response also included a rough estimate for a summer, helicopter supported drill program. The helicopter program estimate indicated lower mobilization costs, less logistical coordination problems and lower drilling costs due to the portability of the helicopter drilling equipment and less extreme climatic factors.

After the ASTS evaluation and comparison of the drill bids, it was determined that a meeting with the designated NSB Department of Public Works representative be held to discuss a possible change in plans and schedule to conduct a summer, helicopter supported program. ASTS believed that the significant cost savings and logistical advantages of the summer helicopter program independently proposed by Salisbury and Dietz was worthy of consideration by the program team.

A meeting was held in March 1981 at the ASTS office with Mr. Irving Igtanloc, DPW-NSB. Mr. Igtanloc provided ASTS with additional information concerning the apparent onset of an earlier-than-usual breakup which could significantly hamper a ground-mobile drilling operation. After this meeting and with the approval of the NSB, it was decided to accept the helicopter program proposed by Salisbury and Deitz, but to ask for a more detailed, not-to-exceed cost estimate from the selected contractor. The amended bid was accepted by ASTS.

Lodging and accommodation requirements were coordinated through ASTS and the NSB. The final contract was signed and approved by the NSB in June 1981.

3.3 Task 3 Exploratory Drilling Program

The exploratory drilling program began after receipt of all federal and state permits and appropriate letters of non-objection and permission. The drilling program was conducted under the direct supervision of ASTS personnel.

Mobilization of equipment and personnel to Fairbanks occurred on June 27, 1981. Due to inclement weather and Instrument Flight Rules (IFR) weather on the North Slope, both at Wainwright and Anaktuvik and Atigun Passes, mobilization to the North Slope was delayed until July 3, 1981. ASTS geologists and drill contractor crews and equipment were mobilized by Pacific Alaska Airlines in a Fokker (F-27) twin turbo-prop aircraft to the LIZ-3 DEW Station near Wainwright. Alaska Helicopters Inc., Bell 206B Jet Ranger departed Fairbanks early in the morning on July 3 and arrived at Wainwright in the late afternoon of the same day. All drill equipment was unloaded at the LIZ-3 DEW station airstrip pending sling loading to drill area C for set-up and operation. The drill crew and ASTS geologists transferred personal equipment to the NSB-owned contruction camp in Wainwright via helicopter.

Accommodations were provided in this camp for the duration of the drill program. After two inclement weather days which precluded helicopter flight, drilling commenced on July 5, 1981. After drilling 19 boreholes (approximately 1953 L.F.) the program was terminated on August 3, 1981.

3.3.1 Methods of Investigation

The drilling was scheduled to begin in area C due to distance from the village of Wainwright. Concurrently with moving and staging the drilling and geophysical equipment, the ASTS geologists located borehole number C-1, by Brunton compass and tape (topofil) measuring from aerial-photograph-identifiable topographic features. After locating borehole C-1, the primary and alternate borehole grid pattern for area C was established using compass and tape triangulation techniques. All subsequent borehole locations were flagged, staked and marked to expedite helicopter supported drill equipment moves. Borehole locations were confirmed through helicopter surveillance at medium altitude (approximately 2,000 feet). The air photos which covered the location were then pinpricked for future use. Borehole locations and patterns in drill areas A, B, and D were similarly established. After completion of drilling in area C, necessary drilling equipment was sling loaded to area D and auxilliary equipment was left at area A (A-1) for stockpiling and to allow for an orderly drilling sequence that would terminate at A-1 prior to demobilization. Drilling was accomplished sequentially in area C, area D, area B, and finally terminated in area A at the equipment stockpile location.

3.3.2 Drilling Equipment:

The drilling equpment used to conduct the exploratory coal coring program consisted of the following equipment:

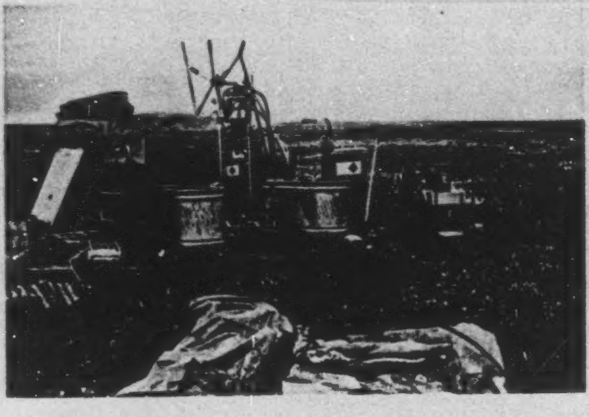
- GW-15 Winkie drill, aluminum skid mounted, (helicopter portable) modified to utilize a Hatz one cylinder diesel powerplant coupled with hydraulic pump, fluid reservoir, and hydraulic motor operating at a nominal rotary pressure of 1000-1500 pounds per square inch (psi). The GW-15 Winkie drill had an operating range of 500 rod RPM to 1300 rod RPM with torque values of approximately 70 to 40 ft.-lbs., respectively.
- BW 44 Christianson 5 foot and 10 foot core barrels.
- Christianson and JKS set and impregnated diamond core bits, reaming shells and casing shoes.
- BW aluminum drill rods of 1, 2, 3, 5 and 10 foot lengths (200 total linear feet).
- BW steel, flush couple casing (1, 2, and 3 foot length), (2.875 in. OD).
- Honda G-150 and G-200 engines coupled with Robbins and Myers type pumps for circulation of drilling fluids and drill water acquisition.
- Two galvanized steel stock tanks (150 gallon and 175 gallon) for drill fluid mixing and recirculation.
- Ancillary tools, plywood sheets, drill and engine, spare parts, boxes, PVC pipe and drill fluid (Quick-trol and methanol).

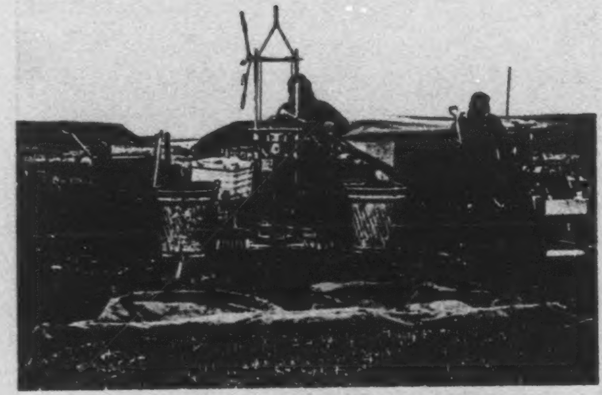
3.3.3 Operation and Downhole Drill Conditions

The drill equipment was crated for transport and mobilization and assembled in the field. All equipment was designed to break down into discreet units of less than 1,000 lbs. for movement with a Bell, 206B Jet Ranger helicopter. Movement of drill equipment was accomplished by helicopter using nylon cargo nets, nylon slings, steel cable chokers and carabiner/chay slings.

Figure 3-3 shows a typical drill site set up. The boreholes were usually located on low and high center polygonal ground. This was done to ensure good, relatively dry ground conditions for equipment set-up and operation (including geophysical equipment), a stable work surface in the slightly marshy and hummocky tundra, and to minimize the disturbance to the vegetative mat during drilling operations. The area for the GW-15 Winkie drill rig was leveled to insure a good ground anchor and plumbness of the borehole. The galvanized steel stock tanks were placed on the rig's aluminum skids to add weight when full with water. Plywood sheets were distributed around the immediate drill area for working surface and ancillary equipment set ups. By locating both the boreholes and drill equipment set-ups near the edges of polygonal ground, the low-lying "crack" or "fissure" was lined with vinyl tarps and utilized as a drill cuttings sump and recirculation pit. This set-up also aided in the settlement, evaporation and dilution of the methanol-water-Quick-Trol drilling fluids.

To ensure drill cuttings (sand, silt, clay) removal, diamond core bit and casing shoe lubrication, and to minimize permafrost degradation, and drill rod icing, a mixture of surface





PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

11-81

FIGURE 3-3: Drill site set-up

water, Quick-Trol or Drill-Trol and methanol was used. Quick-Trol and Drill Trol are biodegradable polymer type drill additives. Within two to three days, the gray, sediment contaminated drill fluid would decompose to clear water with 100% drill cutting settlement. A nominal solution of approximately 2 percent methanol was used to depress the freezing point of water and to prevent borehole icing. When downhole icing conditions were encountered, a nominal solution of 20 percent methanol was circulated to free the drill tools. Non-phosphate detergent was added in areas of swelling clays for lubrication purposes. A nominal (approximate) 1,200 gallons of water drilling fluid was used per borehole with recirculation techniques used to conserve both water and methanol usage.

Within the four drill areas, subsurface drilling conditions were fairly consistent. BW flush couple steel casing was drilled through the silty, sandy, gravelly overburden and collared in competent bedrock. A Christianson BW set diamond casing shoe was used to penetrate the overburden. Penetration rates were quite fast (approximately 5 ft/3-10 minutes) with some sand washouts due to the effect of the circulating drilling fluid and varying downhole ice conditions. The washouts were predominant where stratified and massive ice was encountered in the near surface sediments (<20 ft). In boreholes containing significant amounts of gravel, increased drilling difficulties were encountered, including decreased penetration rates and increased pilot bit and casing shoe wear. Pilot coring was used to clean and flush the casing of uncirculated sand and gravel cuttings. A very limited amount of overburden core was recovered. Pilot coring was also utilized to determine the cmpetency and ice content of the bedrock for casing collaring. The first few feet of bedrock was ice rich, fractured, and broken, and yielded moderate core recovery (Figure 3-4a). Inspection of the geophysical caliper logs indicated moderate annular washouts at the bottom of the casing and extensive washouts in bedrock containing stratified and random ice lenses. Drilling rates, hole conditions and bit wear varied with subsurface lithology. Generally, core recovery in non-coal bearing rock was good, with recovery ranging from 85 to 100 percent. In poorly indurated, ice-rich silty-claystones with swelling properties, penetration rates decreased (5 ft/25 min.) and frequent rod trips were required to clean the plugged bit and core barrel. Non-phosphate detergent was added to the drill fluid to partially mitigate these problems. Swollen clay bridges were also encountered during downhole rod trips. Moderately to well indurated siltstones and sandstones were penetrated (5 ft/10 min.) and cored effectively, with some core barrel blockage in zones containing stratified and random ice lenses and thin bedded sediments. Penetration rates in the coal beds were quite rapid (5 ft/5 min.) with some core barrel blockage due to the friable and broken nature of the coal (Figure 3-4b). Coal recovery varied between 95 to 100%. Rotary drilling pressures varied from 1000 to 1300 psi in bedrock with mud pump pressures of 80-120 psi. Overburden drilling was rapid in sands and silts with penetration rates of 5 ft/3 min. and rotary and mud pressures of 500 psi and 80 psi respectively. In fine grained overburden the drill would penetrate under its own weight, using no down pressure or crowding.

All recoverd core was measured, logged, and classified in the field. Bedrock and thin, non-mineable coal seam core was boxed and labeled for storage and office evaluation. The core

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH-
WAINWRIGHT COAL STUDY

FIGURE 3-4a: Example of core recovery in the Corwin Formation

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

11-81

FIGURE 3-4b: Examples of core recovery in coal beds

from mineable coal seams was recovered, logged and double-bagged in plastic for in situ moisture preservation and subsequent coal quality testing. All bedrock and coal core was stored in Wainwright during the field drilling program and subsequently transshipped to Seattle and Golden, Colorado for storage, evaluation and coal quality testing.

In the course of the normal drilling operation, the following sequence of procedures was used to complete the borehole to the desired depth and recover rock and coal core for classification, identification, and subsequent coal quality analysis:

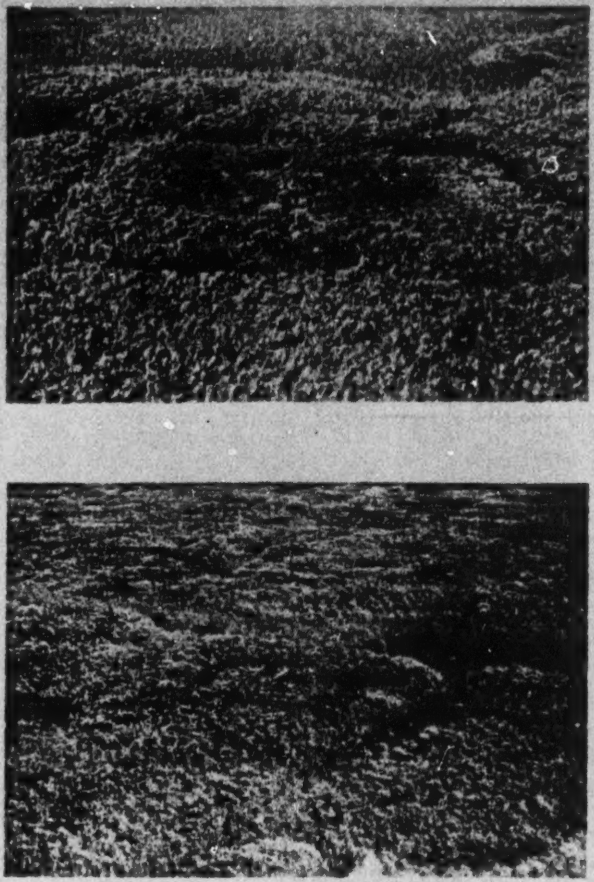
- Locate borehole, prepare site for drill equipment;
- Move drill/geophysical equipment to site;
- Drill equipment set-up, assembly and daily maintenance;
- Locate and establish, using PVC pipe and pump, the surface water for drill fluid mixing;
- Drill, set and collar BW steel, flush couple casing through frozen sands and gravel overburden into underlying competent bedrock. Use BW drill rods and 5 foot core barrel to clean sands from casing during the casing sequence. Pilot cores were used to establish the bedrock horizon for collaring purposes;
- Bedrock and coal seam coring using 5 and/or 10 foot BW-44 core barrels depending on rock quality and permafrost conditions;
- Core recovery and lithologic logging, labeling and placement in core boxes; (Figures 3-4 a and b)
- Coal core recovery, logging and sample preparation (plastic sample bags were used for in-situ moisture preservation);

- Completion of borehole to desired depth with final circulation and drill cutting flushing to clean hole for subsequent geophysical logging;
- Geophysical logging using natural gamma, gamma-gamma, high resolution density, and caliper tools;
- Removal of casing;
- Drill equipment tear down, pre-clean up and preparation for next sling move;
- Two to six day natural site drainage prior to rehabilitation and clean-up;
- Site rehabilitation, including backfilling of borehole, replacement of disturbed tundra and ASTS inspection for compliance with federal and state permit stipulations. (Figures 3-5)

In the course of the field drilling operation, the designated BLM-NPR-A field inspector checked the operation for compliance with federal permit stipulations. The BLM-NPR-A inspector was shown all phases of the drilling operation, including on-going drilling/coring, geophysical logging, pre-staked borehole locations, and rehabilitated drill sites. The inspector indicated that ASTS was in compliance and running a clean operation. The Wainwright City Council and Mayor were also given the opportunity to inspect the various phases of the drilling operation.

3.3.4 Geophysical Equipment

Downhole geophysical logging equipment and the geophysicist/operator were provided by Digilog, Inc. Digilog, Inc. is a borehole geophysical exploration company providing logging and consulting service for the minerals industry. Digilog, Inc.



PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

11-81

FIGURE 3-5: Drill site rehabilitation after removal of equipment

provides a helicopter portable, self-contained, one piece geophysical logging unit consisting of modular digital electronic units and downhole probes. Specific units comprising the helicopter-portable logging system are described below:

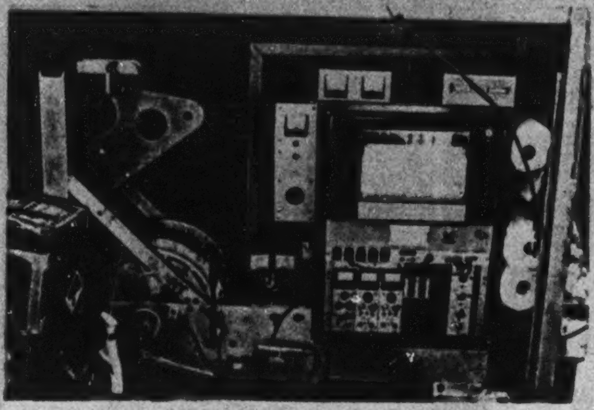
- o Rate meters - Gearhart Owens, Inc., RM-1 modular, pulse type rate meters
- o Chart Recorder - Texas Instrument, four channel with digital coding capabilities
- o Downhole Probes - Comprobe Model 104 high resolution density probe; Comprobe Model 104 high resolution natural gamma probe and Comprobe caliper tool
- o Nuclear source capsule of Americium (Am-241), 20 millicurie rating
- o Honda E-2500K generator, rated at 115 volts, 2000 watt AC output, for logging equipment power supply

Figures 3-6a and b show the geophysical equipment and downhole probes used on the Wainwright coal study exploratory drilling program.

Geophysical Logging Operation

Upon completion of each borehole to depth, the hole was circulated clean of all drill cuttings to insure open hole conditions for geophysical logging. The geophysical logging procedures are as follows:

- Generator maintenance and warm up;
- Rate meter, chart recorder and electronic equipment warm up;
- Installation of nuclear (Am-241) source and assembly of downhole probe. Downhole probe warm-up;



PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

11-81

FIGURE 3-6a: Electronic configuration of the Digilog equipment

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

11 81

FIGURE 3-6b: Loading the geophysical probe and nuclear source

- Placement and descent of probe into the borehole;
- Borehole logging upon ascent of probe;
- Secondary and tertiary logging runs, if required by downhole conditions;
- Probe disassembly and equipment shut down;
- Retrieval and recording of appropriate data on log strip chart;
- Field comparison of geophysica|log and core lithology.

Downhole conditions were a critical factor during the geophysical logging operation. Stable borehole wall conditions and relatively clean drill fluid returns are optimum conditions for the production of the geophysical log. During the Wainwright drilling operation a number of holes were in a deteriorated condition and only a single pass with the geophysical probe was possible. It was not possible to obtain caliper logs in 5 of the borings and no geophysical logs were obtained in three holes. Some clay-gravel bridging conditions were also encountered in holes with swelling clay seams and gravel washouts. Two significant problems were encountered during the downhole logging operation: 1) electronic short circuit of the Comprobe Model 104 high resolution density probe due to infiltration of drill fluids in the probe casing; and 2) a stuck probe due to falling gravels and swelling clays. Overshot fishing and reaming methods were used to retrieve the geophysical probe. It was retrieved undamaged. Another condition that may have effected the geophysical logs was cold (20 F) drill fluid temperatures within the borehole. Evaluation of the geophysical logs in comparison to the recovered core lithology confirmed the depths, intercepts and thickness of the coal seams investigated.

Coal Quality Testing Program

Prior to the exploratory drilling program, a tentative coal quality testing program was planned. After completion of all core drilling and evaluation of subsurface coal data in conjunction with both the mining and power generation engineering group, the following coal quality testing program was implemented.

All individual coal seams of mineable interest were sampled and subjected to both an Ultimate and Proximate analyses tests. Ultimate analysis determines the weight percent of the following chemical constituents: moisture, ash, sulfur, carbon, hydrogen, nitrogen, and oxygen by difference. Proximate analysis determines the weight percent of the following chemical constituents: moisture, ash, sulfur, volatile matter and fixed carbon. The heat value per pound (BTU content) was also determined. The resul of these tests are presented in Section 3.4.6 and Tables 3-2 through 3-7.

After individual ultimate and proximate analyses were run, composite samples of the mineable seams in each drill area (A-B,C,D) were composed and subjected to the following tests for mining and combustion engineering determinations of various design parameters:

- Composite sample ultimate and proximate analysis;
- Composite sample fusion temperature of ash (oxidixing and reducing atmosphere;
- Composite sample forms of sulfur;
- Composite sample equilibrium moisture determinations;

- Composite sample free swelling index tests (2 samples);
- Composite sample Hardgrove Grindability Index tests;
- Composite sample specific gravity determinations;
- Composite sample 10 elemental analysis of ash;
- Composite sample trace element mass spectroscopy.

Determination of the coal rank and results of these tests are presented in Tables 3-2 through 3-7, in Section 3.4.6.

3.4.0 Task 4 Data Analysis and Geologic Interpretation

3.4.1 Introduction

The coal study centered around the village of Wainwright (70 , 37', 30" N. latitude, 160 00'00" longitude) on the North Slope of Alaska (Figure 3-1). Wainwright, which is approximately 100 miles west-southwest of Barrow, is located near the mouth of the Kuk river on the Chukchi sea (Figure 3-2).

Wainwright is in the Arctic Coastal Plain physiographic province as defined by Wahrhaftig (1965). The Arctic Coastal Plain is a tundra environment with numerous northwest-southeast trending thaw lakes, immature drainage patterns, and an almost total lack of significant topographic relief. The maximum elevation within the study area is 92 feet. Lakes occupy 25 to 30 percent of the landscape (Walker and others

1980). Located in the continuous permafrost zone (Figure 3-1), the Arctic Coastal Plain is marked by numerous polygonal ground patterns created by frost wedging (Updike and Howland 1979 and Walker and others 1980). The most common of these polygonal patterns is the low-centered polygon which, together with areas of high-centered polygons, make-up the principal microrelief. Other topographic features that contribute to the microrelief of the area include hummocks (located primarily along river banks), pingos, active and vegetation-stabilized sand dunes near rivermouths, the slight depressions where rivers incise in to the tundra, and the bluffs along streams and the ocean.

Major hydrographic features of the area are the Kuk River, Wainwright Inlet, and the Sinaruruk and Kungok Rivers.

Permafrost underlies the entire area to depths ranging from 1,000 to 2,000 feet (Payne and others 1951, Ferrians 1965, Grantz and others 1980, and March 1980). The measured thickness of the active layer ranged from 0.8 feet to 2.0 feet. Ice was present in many forms including nonvisible, visible - less than 50 percent, and massive ice (Figure 3-7).

3.4.2 Regional Geology

In the Wainwright area, the near-surface stratigraphy consists of an organic tundra mat overlying two to five feet of Holocene age eolian silt and sand (Figure 3-8). This sediment mantles the Pleistocene age Gubik Formation which consists of unconsolidated beach and fluviatile deposits (Figures 3-9 and 3-10). The Gubik Formation ranges from twenty to sixty feet thick in the area and consists of ice-rich, unconsolidated

ICE DESCRIPTIONS

GROUP SYMBOL	ICE VISIBILITY & CONTENT	SUBGROUP	
		DESCRIPTION	SYMBOL
N	Ice not visible	Poorly bonded or friable	N_f
		Well-bonded: No excess ice	N_b: N_{bn}
		Well-bonded: Excess ice	N_b: N_{be}
V	Ice visible, < 50%	Individual ice crystals or inclusions	V_x
		Ice coatings on particles	V_c
		Random or irregularly oriented ice formations	V_r
		Stratified or distinctly oriented ice formations	V_s
ICE	Ice visible, > 50%	Ice with soil inclusions	Ice + soil type
	Individual layer > 6" thick *	Ice without soil inclusions	ICE

* In some cases where the soil is ice poor a thin ice layer may be called out by special notation on the log, i.e. 2" ice lens at 7'.

FIGURE 3 -7 : Ice description system, after Linell and Kaflar, 1966

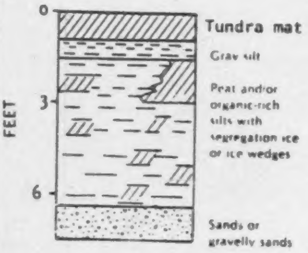
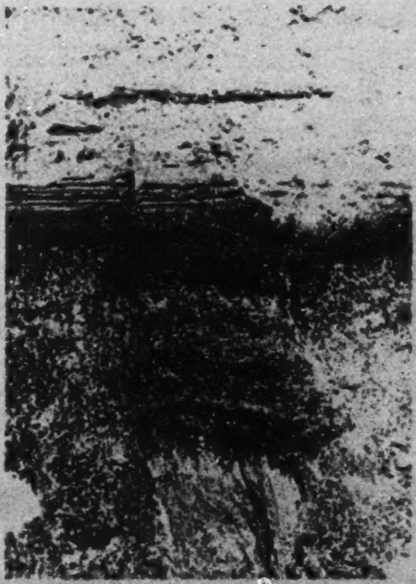

0
3
6
FEET
Tundra mat
Gray silt
Peat and/or organic-rich silts with segregation ice or ice wedges
Sands or gravelly sands

FIGURE 3 -8 : Generalized stratigraphic section of the near surface deposits in the drill areas, after Walker and others 1980, p. 9

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

11-81

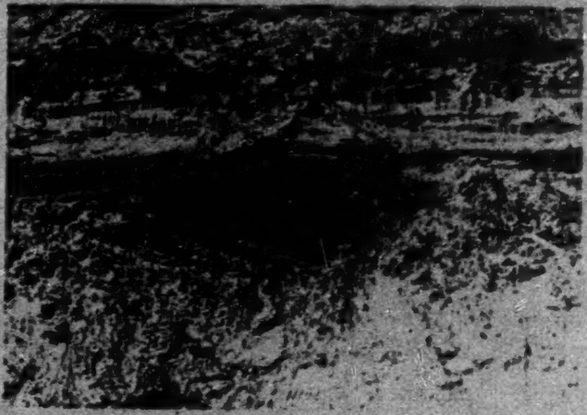
FIGURES 3-7 and 3-8.



PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

11-81

FIGURE 3-3 : Beach bluff exposure of the Gulik Formation



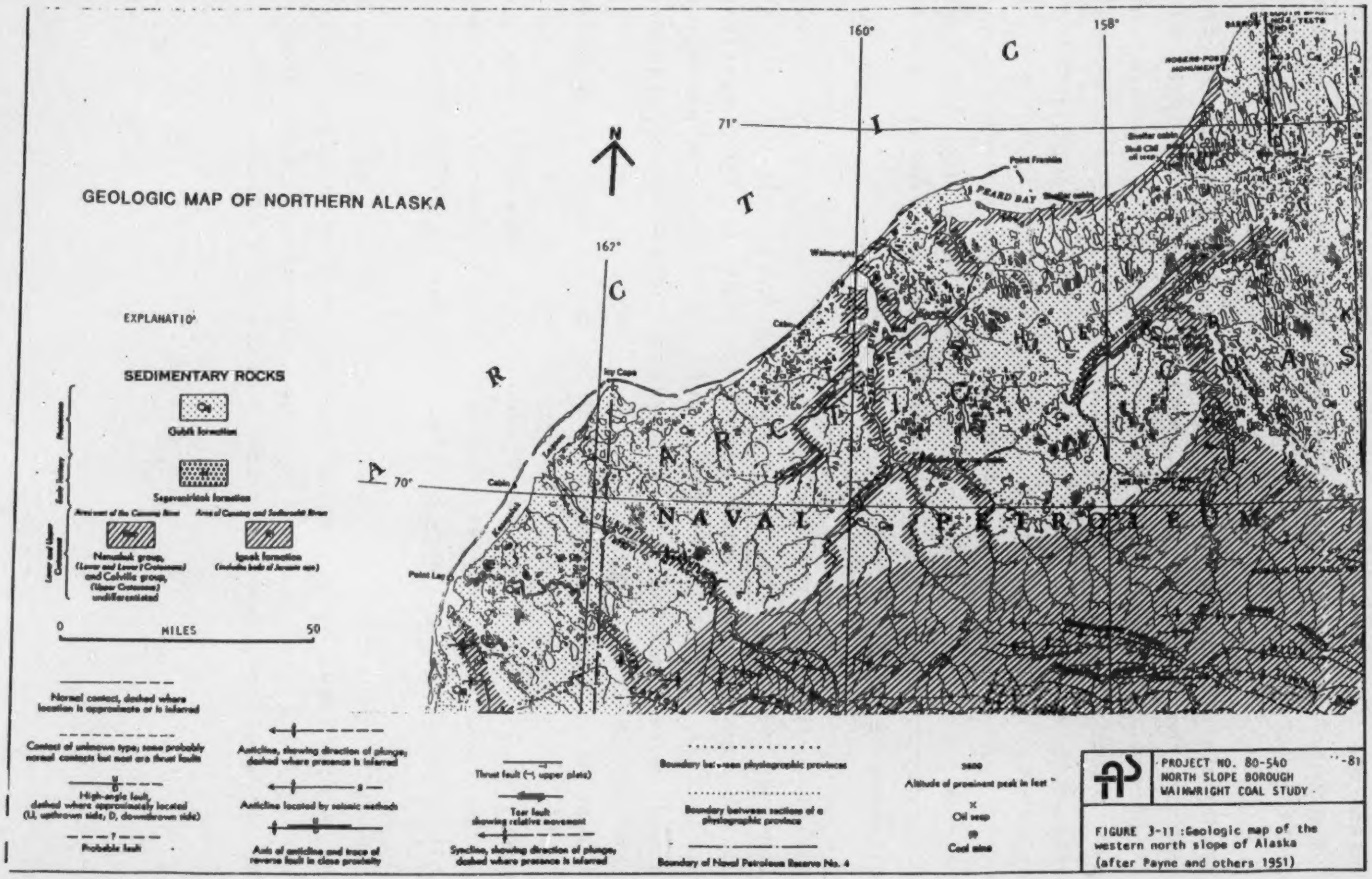
PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-10 : Eolian silt overlying fragments of coal in well to poorly stratified yellowish sands and silts of the Gubik Formation

silt, sand, some gravel, coal fragments, shell material, and wood fragments. The sediments are generally thin to moderately thick bedded (from 0.1 foot to 2.0 feet thick), moderately sorted, and often laterally continuous. There are some beds which are comprised almost exclusively of coal fragments that have been derived from the many coal seams that crop-out in the river banks. These coally beds tend to be thicker than the other beds. Fine grain sediments underlie the detrilal coal beds in many areas.

The sediments of the Gubik Formation were deposited as sheetwash on flood plains, as point bars along river banks, as deltas, and as ocean beaches. The sediments and structures present are indicative of low- to moderate-energy environments of deposition. The sediments are fairly-sorted, well-graded, with a moderate to high grain-matrix ratio. Shell material is usually unbroken, and fragments of plant remains are present. Sedimentary structures include fine laminations, abundant cross-bedding of variable thickness, asymmetrical and symmetrical ripple marks, lenticular bedding, and a landward or southerly dip. Pettijohn and others (1973) report that these textures and structures are indicative of deltaic-beach interaction.

The Gubik formation rests unconformably on a progradational molasse sequence of shallow marine sandstones and shales to non-marine, deltaic and interdeltaic, coal-bearing sandstones of the early and late Cretaceous Nanushuk Group (Payne and others 1951, NPRA 1978, Ahlbrant 1979, and Martin 1980) Figure 3-11. The Nanushuk Group in this area consist of two formations, the marine sandstones and shales of the Kukpowruk Formation and the non-marine coal-bearing sandstones and


GEOLOGIC MAP OF NORTHERN ALASKA
EXPLANATIO'
SEDIMENTARY ROCKS
Gubik formation
Sagavanirktok formation
Area west of the Canning River
Area of Canning and Sadlerochit Rivers
Nanushuk group, (Lower and Lower ? Cretaceous) and Colville group, (Upper Cretaceous) undifferentiated
Ignek formation (includes beds of Jurassic age)
0 MILES 50
Normal contact, dashed where location is approximate or is inferred
Contact of unknown type; some probably normal contacts but most are thrust faults
High-angle fault, dashed where approximately located (U, upthrown side; D, downthrown side)
Probable fault
Anticline, showing direction of plunge; dashed where presence is inferred
Anticline located by seismic methods
Axis of anticline and trace of reverse fault in close proximity
Thrust fault (upper plate)
Tear fault showing relative movement
Syncline, showing direction of plunge; dashed where presence is inferred
Boundary between physiographic provinces
Boundary between sections of a physiographic province
Boundary of Naval Petroleum Reserve No. 4
Altitude of prominent peak in feet
Oil seep
Coal mine
N
A R C T I C
O C E A N
71°
70°
162°
160°
158°
Point Franklin
PEARD BAY
Wainwright
Icy Cape
Point Lay
NAVAL PETROLEUM
ARCTIC COASTAL PLAIN

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-11 :Geologic map of the western north slope of Alaska (after Payne and others 1951)

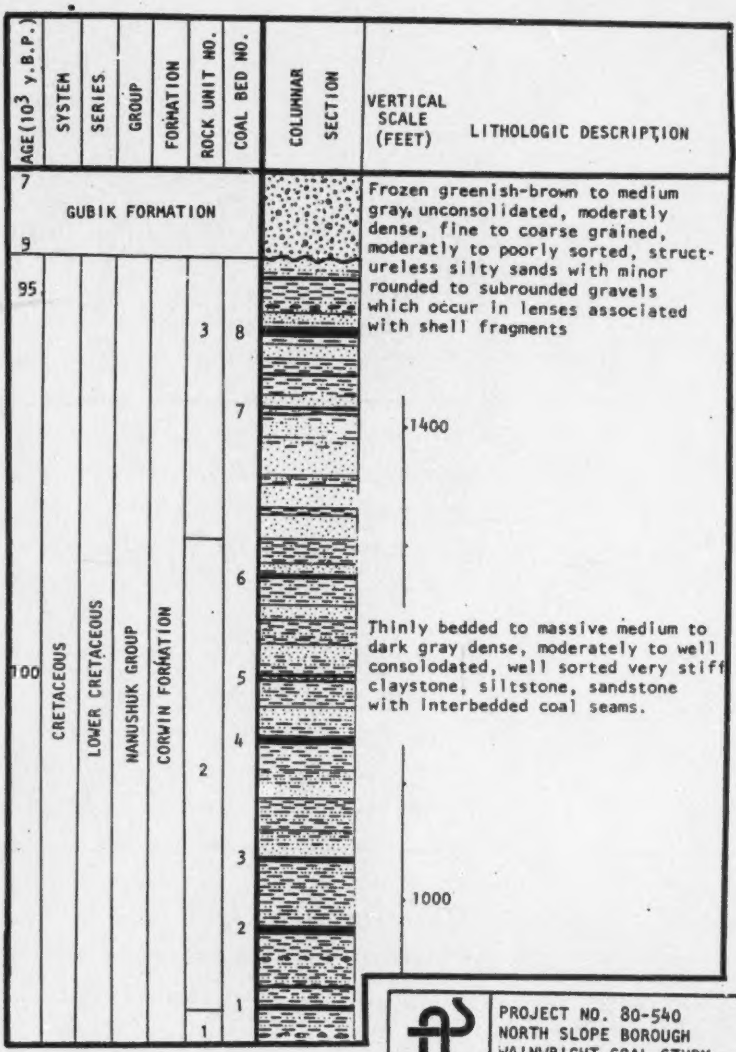
shales of the Corwin Formation (Figure 3-11). This study concentrated on the coal bearing horizons of the Corwin Formation (Figure 3-12).

The Corwin Formation is approximately 1,000 to 1,200 feet thick in the Wainwright area (Martin and Callahan 1978, Bird and Andrew 1979, and Mull 1979) and can be subdivided into four informal rock units. (Figure 3-12) The lowermost, designated Rock Unit One, consists of claystone, siltstone, sandstone, coal, and siderite (Martin 1980). The coal is thinly bedded and has a higher sulfur content than coals in the overlying units (Martin 1980). The depositional history and environments will be discussed in more detail in the following section

Overlying the lowermost unit is Rock Unit Two of similar lithology to Unit One. The coal in this unit is tabular, thicker, and areally more extensive than in the underlying unit. This suggests that the swamps where the coal seam were formed were located on widespread, stable, depositional platforms (Martin, 1980).

Rock Unit Three overlies Rock Unit Two and is comprised chiefly of sandstone with lesser amounts of claystone, siltstone, coal, and ironstone (Figure 3-13). The coal beds tend to be less frequent yet thicker than those of Unit Two, indicating longer periods of stability during deposition.

Rock Unit Four, the uppermost strata, occurs to the south of the study area. This unit consists predominantly of claystone, siltstone, sandstone, and siderite. According to Martin (1980) the coal beds are locally much thicker, more


AGE (10³ y.B.P.)
SYSTEM
SERIES
GROUP
FORMATION
ROCK UNIT NO.
COAL BED NO.
COLUMNAR SECTION
VERTICAL SCALE (FEET)
LITHOLOGIC DESCRIPTION
7
GUBIK FORMATION
9
95
100
CRETACEOUS
LOWER CRETACEOUS
NANUSHUK GROUP
CORWIN FORMATION
3
2
1
8
7
6
5
4
3
2
1
1400
1000

Frozen greenish-brown to medium gray, unconsolidated, moderatly dense, fine to coarse grained, moderatly to poorly sorted, structureless silty sands with minor rounded to subrounded gravels which occur in lenses associated with shell fragments

Thinly bedded to massive medium to dark gray dense, moderately to well consolodated, well sorted very stiff claystone, siltstone, sandstone with interbedded coal seams.

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-12 Geologic column of the Corwin Formation.

After Martin, 1980

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-13: Typical outcrop of the Corwin Formation along the Kungok River south of Wainwright

lenticular, contain or are observed to develop frequent rock partings, and have lower sulfur contents than coals in underlying units.

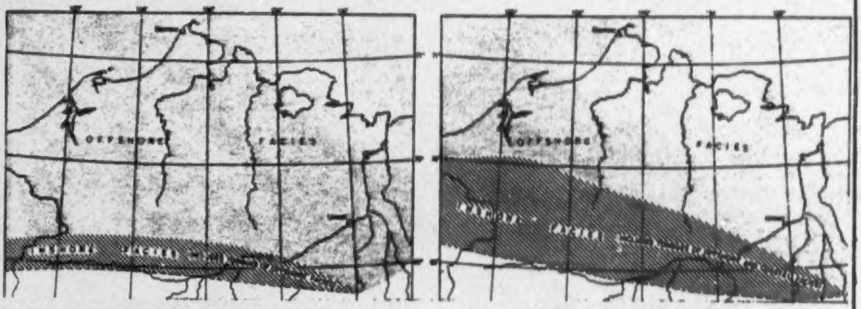
Rock Units Two and Three contain the coal bearing horizons (beds 1 through 8) that are of interest in this study.

Units One and Four are not of interest in this study because Unit One coal seams occur too deep to mine economically and Unit Four coal seams have been erosionally removed in the project area.

3.4.3 Depositional History and Environment

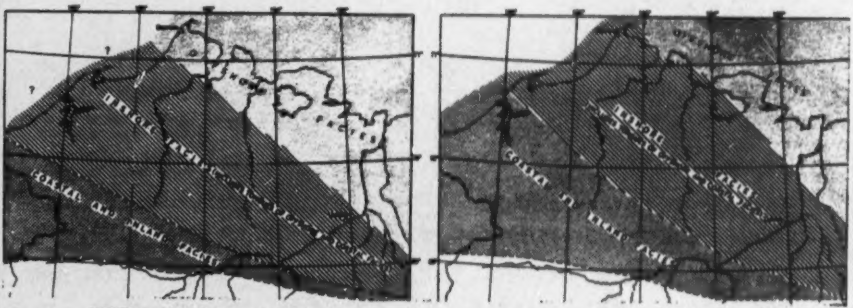
The Nanushuk Group sediments record the progressive filling of the Colville basin, a deep asymmetric foredeep (exogeosyncline) north of the Brooks Range orogenic belt, and may be considered a typical gradational flysch to molasse (marine sedimentary facies to a partly marine, partly continental or deltaic sedimentary facies) sequence, with the rocks of the Nanushuk Group representing post-Orogenic molasse deposits (Mull 1979) (Figure 3-14). In the Wainwright area, the Kupowruk Formation represents the shallow water marine transition phase of the molasse sequence. This formation is overlain by the nonmarine, continental Corwin Formation. Sediments in these formations were derived from uplifted areas in the vicinity of the Brooks Range and areas west extending beneath the Chukchi Sea. Locally these sediments filled the depocenter termed the "Corwin Delta" (Martin 1980).

Detailed studies by Martin and Callahan (1978), Ahlbrandt and others (1979), Mull (1979), and Stricker (1979), indicate that


OFFSHORE FACIES
INSHORE FACIES
OFFSHORE FACIES
INSHORE FACIES

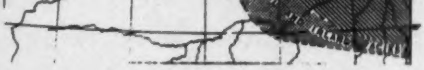
LOWER MIDDLE CRETACEOUS

MIDDLE CRETACEOUS


?
?
OFFSHORE FACIES
INSHORE FACIES
COASTAL AND INLAND FACIES
OFFSHORE
INSHORE FACIES
COASTAL AND INLAND FACIES

UPPER MIDDLE CRETACEOUS

LOWER UPPER CRETACEOUS


OFFSHORE FACIES
TULUGA MEMBER AND ITS NONMARINE EQUIVALENT ABSENT IN MOST OF AREA WEST OF IKPIKPUK RIVER AND SIMPSON PENINSULA
INSHORE FACIES
COASTAL AND INLAND FACIES

UPPER CRETACEOUS

Depositional history of the Cretaceous coal bearing strata in the Wainwright area, showing the progression from a deep water offshore marine facies, to an inshore facies, to coastal and inland facies, to a period of non-deposition

(After: Payne and others 1951)

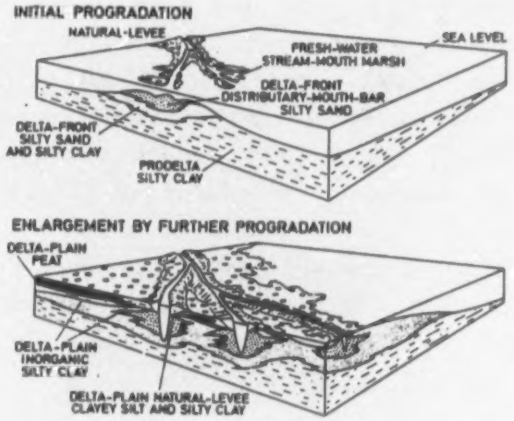
PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-14:

Depositional history of the Nanushuk Formation during the Cretaceous the majority of coals were formed on an alluvial plain consisting of a complex of shifting distributary channels, swamps, and floodplains. A typical prograding-deltaic sequence is shown in Figure ?3-15 (Pettijohn and others 1973). As more detritus is deposited, the channels move and leave behind swamps where peat can form. Peat deposits forming on the middle to lower portions of the delta-plain are collectively more widespread, as are the coal beds of Rock Unit Two. Peats forming in the coastal portions of the delta-plain are thin and discontinuous relative to the inland peats (i.e. Rock Units Two and Three) due to the constant shifting of the channels. The thick mudstone and siltstone interbeds in Rock Units Two and Three are indicative of upland deltaic-plain sedimentation, as flooding would tend to blanket the area with fine grain sediment but would not alter the channel location as it might occur downstream.

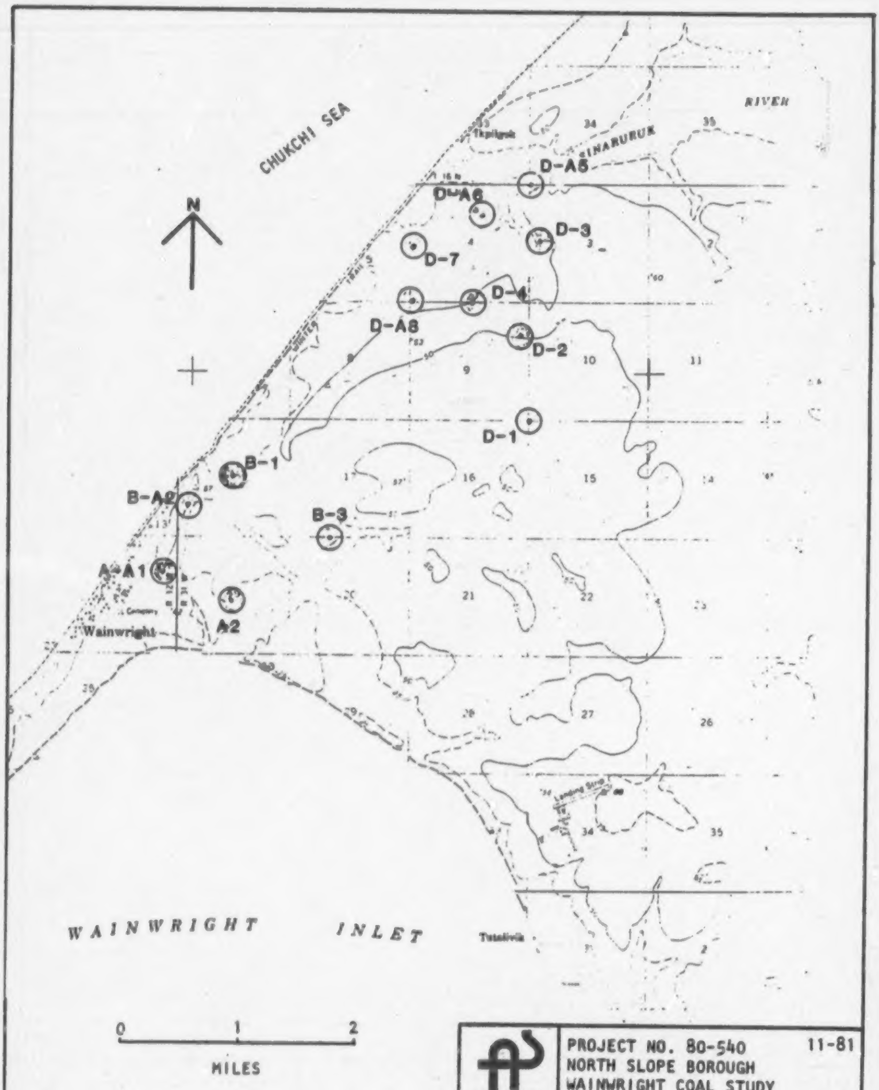
3.4.4 Drill Areas - Detailed Geology

Boreholes were assigned to drill areas on the basis of proximity to each other and on the potential similarities of the subsurface geology (Figure 3-16 and 3-17, Table 3-1). The topography and morphology of each area differ, but the subsurface conditions remain the same in the upper five to seven feet. The tundra mat consists of organic matter, silt, and fine sand and at the time of drilling was thawed to a minimum depth of approximately eight inches and a maximum depth of two feet. Permafrost was present as massive, stratified, or nonvisible-bonded ice (see Figure 3-7 for ice descriptions). Slightly sandy silt, of the Gubik Formation, is either brownish-green or greenish-gray and underlies the tundra mat to depths up to 60 feet. There is much variation of sediment


INITIAL PROGRADATION
NATURAL-LEVEE
SEA LEVEL
FRESH-WATER
STREAM-MOUTH MARSH
DELTA-FRONT
DISTRIBUTARY-MOUTH-BAR
SILTY SAND
DELTA-FRONT
SILTY SAND
AND SILTY CLAY
PRODELTA
SILTY CLAY
ENLARGEMENT BY FURTHER PROGRADATION
DELTA-PLAIN
PEAT
DELTA-PLAIN
INORGANIC
SILTY CLAY
DELTA-PLAIN NATURAL-LEVEE
CLAYEY SILT AND SILTY CLAY

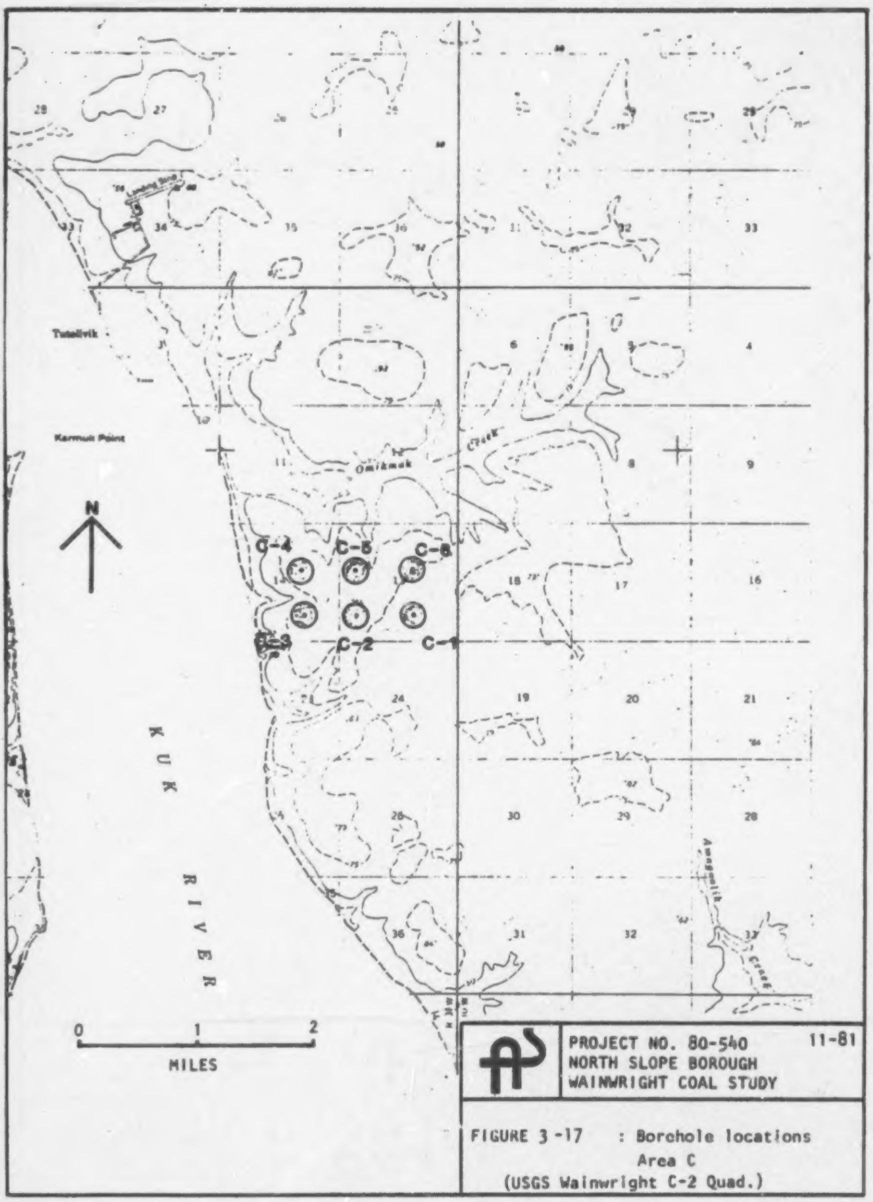
PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-15: Prograding delta facies and variations in peat formation (after Pettijohn and others 1973 p. 468)


CHUKCHI SEA
N
RIVER
D-A5
D-A6
D-3
D-7
D-4
D-A8
D-2
D-1
B-1
B-A2
B-3
A-A1
A2
Wainwright
WAINWRIGHT INLET
0
1
2
MILES

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-16 : Borehole locations for areas A-B and D
(USGS Wainwright C-2 Quad.)


Tutolivik
Karmuk Point
Omikmak Creek
C-4
C-5
C-6
C-3
C-2
C-1
N
K U K R I V E R
0 1 2
MILES
27
33
34
35
36
31
32
33
6
4
8
9
18
17
16
19
20
21
24
30
29
28
36
31
32

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-17 : Borehole locations
Area C
(USGS Wainwright C-2 Quad.)

TABLE 3-1

BOREHOLE LOCATIONS

	Location						
Borehole	Township	Range	Section	1/4 sec	1/16 sec	1/32 sec	Elevation feet
A-A1	T15N	R32W	24	NE	SE	NW	45
A-2	T15N	R31W	19	SW	NW	NW	26
B-1	T15N	R31N	18	SE	NW	NW	23
B-A2	T15N	R31W	18	SW	SW	NW	50
B-3	T15N	R31W	20	NW	NE	NE	25
C-1	T14N	R31W	13	SE	SW	NE	75
C-2	T14N	R31W	13	SW	SW	NE	85
C-3	T14N	R31W	14	SE	SW	NE	85
C-4	T14N	R31W	14	NE	SW	NE	85
C-5	T14N	R31W	13	NW	SW	NE	85
C-6	T14N	R31W	13	NE	SW	NE	85
D-1	T15N	R31W	corner adjoining secs. 9-10-15-16				45
D-2	T15N	R31W	9	NE	SE	NE	50
D-3	T15N	R31W	3	NW	SW	SW	48
D-4	T15N	R31W	4-9	on section line			50
D-A5	T15&16N	R31W	corner adjoining secs. 33-34-3-4				45
D-A6	T15N	R31W	4	NE	SW	NW	35
D-7	T15N	R31W	4	SW	NW	NW	49
D-A8	T15N	R31W	corner adjoining secs. 4-5-8-9				30

type below two feet as will be discussed later in this section. Geologic columns, cross-sections, and fence diagrams have been generated from the lithologic logs prepared during field drilling. The composite lithologic logs are shown at the same scale and accompanying the geophysical logs (where possible) in Appendix A, Figures 1-18.

Some of the borehole locations selected prior to the drilling program were relocated in the field because of excess surface water, distance from the water source, rough surface conditions at the planned site, or for geologic reasons based on the data from other boreholes.

3.4.4.1 Drill Areas A and B

Drill areas A and B will be discussed together due to the proximity of the holes to one another and the similarity of the subsurface geology.

Drill areas A and B are located within two miles to the east and northeast of Wainwright. Area A includes two boreholes; Area B includes three boreholes. (ee Table 3-1 and Figure 3-16). Boreholes A-A1 and B-A2 are situated on a low ridge that parallels the coast for several miles at approximately 45 and 50 feet of elevation respectively. Boreholes A-2, B-3, and B-1 are situated at approximately 20 to 25 feet elevations on a gentle southeasterly slope. A brief description of the geology of each hole is included. The composite lithologic columns and/or geophysical logs for areas A and B are included in Appendix A as Figures 1 to 5.

Borehole A-A1 was drilled to a total depth of 89.8 feet. One coal seam in excess of one foot is present from 86.7 to 89.2

feet. The tundra mat is one foot thick and the Gubik Formation, which consists of silty sand with intermittant organic rich zones and gravel lenses, is 58 feet thick. A thick gravel rich zone is present from 48 to 59 feet. The Corwin Formation is present below 59 feet. A coal seam .9 foot thick is present from 61.5 to 62.4 feet. Claystone and siltstone are predominant in the lower 30.8 feet of the borehole. Some of the clays are smectitic.

Massive ice is present from 1.5 to 2.5 feet. The remainder of the borehole contains nonvisible bonded with no excess ice. Due to poor hole conditions caused by gravel falling into the hole and the thawing of the borehole wall, no geophysical log was obtained.

Borehole A-2 was drilled to a total depth of 130.0 feet. One coal seam in excess of one foot is present from 91.8 to 94.3 feet. The tundra mat is one foot thick and the Gubik Formation, which consists of silty sand with minor gravel lenses and two very thin oil/carbonaceous bearing horizons, is 35 feet thick. Associated with the organic rich horizons are clay and silty sand. The Corwin Formation is present below 36 feet. Carbonaceous claystones and siltstones predominate down to 119 feet with two thin seams (<.4 foot) of coal at 62.9 feet and the thick coal seam from 91.8 feet to 94.3 feet. Silty sandstone is present from 119 to 130 feet. This sandstone is very dense, dark gray, thinly bedded and/or crossbedded.

The sediments contained nonvisible-bonded with excess ice to 35 feet. From 35 to 62 feet the ice within the sediments was nonvisible-bonded with no excess ice. Visible crystals and stratified ice is present from 62 to 96 feet. Below 96 feet the ice is all nonvisible-bonded with no excess ice. The geophysical log shows a significant peak (increase 17 density) in the gamma gamma density log at the contact between the Gubik and Corwin Formations. The density is lower below the bottom of the casing, which is steel. A significant increase in both natural gamma and gamma gamma of 8 and 11 counts per second (cps) respectively occurred at the coal bed from 91.8 to 94.3 feet. Density is lower below the coal bed. The caliper log shows that the hole retained its integrity below the casing to a depth of 110 feet, where some sloughing was recorded with the hole diameter decreased by .5 inch at 130 feet.

Borehole B-1 was drilled to a total depth of 112.0 feet. Two coal beds in excess of one foot are present, one from 56.0 to 57.8 feet and the other from 94.9 to 102.2 feet. The tundra mat is .8 feet thick and the Gubik Formation, which consists of sand overlying sandy gravel, is 36 feet thick. The Corwin Formation is present below 37 feet. Carbonaceous siltstone and claystones grade into sandstone (<3 feet thick) at 48 feet. Siltstone predominates from 51 to 77 feet where it grades into a sandstone to a depth of 85 feet. The lower 30 feet of the borehole consists of claystone or coal. The claystone is structureless, while the siltstone is thinly laminated.

The upper 2 feet of the borehole was thawed. Massive ice is present from 2 to 3 feet. The sediments contains nonvisible-bonded with excess ice to 37 feet with the lower 75 feet consisting of nonvisible-bonded with no excess ice. The geophysical logs show a drop in both natural gamma and gamma

gamma below the casing. The caliper also shows that there was a significant amount of sloughing immediately below the casing. Gamma gamma density increases significantly (7 cps) at the upper sandstone and by 10 cps at the upper coal. The lower coal bed shows both natural gamma and gamma gamma increases at the lower coal bed by 9 and 17 cps respectively.

Borehole B-A2 was drilled to a total depth of 133.0 feet. Two coal seams in excess of one foot are present, one from 77.1 to 78.9 feet and the other from 117.5 to 124.0 feet. The tundra mat is one foot thick and the Gubik Formation, which consists of fine to medium grained sand with a few thin gravel lenses, is 46 feet thick. The Corwin Formation is present below 47 feet. A thin (.9 foot) coal bed is present from 49.4 to 50.3 feet. Claystone and siltstone with carbonaceous material predominates to a depth of 91 feet. Silty, fine grained sandstone that is cross-bedded, thinly laminated, and contains carbonaceous material along partings is present to the top of the coal bed at 117.5 feet. Siltstone underlies the coal to the bottom of the hole.

Massive ice is present in the section from 1.5 to 2.5 feet. The sediments contained nonvisible-bonded with excess ice to 22 feet and nonvisible-bonded with no excess ice present in the lower 111 feet. Visible ice crystals coating grains and interstitial ice occur pervasively between 50 and 62 feet. The geophysical logs show that natural gamma and gamma gamma densities decrease by 20 cps. The upper of the three coal beds was inside the casing and does not register as a significant density increase. The lower coal beds that are greater than one foot thick are reflected in the gamma gamma log by density increases of 10 cps for the bed at 77.1 feet and 16 cps for the bed at 117.5 feet.

Borehole B-3 was drilled to a total depth of 126.8 feet. Three coal seams in excess of one foot are present; one from 48.0 to 51.0 feet, another from 107.8 to 109.6 feet, and the deepest from 112.0 to 115.0 feet. The tundra mat is approximately 1.0 foot thick and the Gubik Formation, which consists of silty sand, sand, and thin organic rich zones, is 16 feet thick. The Corwin Formation is present below 17 feet and consists of interbedded claystone, silty claystone, coal beds, carbonaceous rich, thinly bedded siltstone, and shaley siltstone except between 83 and 89 feet where sandstone is present. A thin coal bed is present from 33.1 feet to 34.0 feet.

The active layer was thawed to a depth of 1.5 feet. The underlying sediments were nonvisible-bonded with excess ice to 34 feet. Excessive ice occurred within thin layers of sediment containing visible ice crystals around grains, random crystals, and stratified ice. Nonvisible-bonded with no excess ice was present in the sediment from 34 to 126.8 feet. The geophysical logs show a steady decrease in the density throughout the upper 33 feet. The density increases in both the natural gamma and gamma gamma logs in the lower three coal beds and shows the split in the lower two coal beds. The upper of the three beds shows an 11 cps increase while the lower two show 7 cps increases. There is also a noticeable increase in the density from 83 feet to 89 feet due to the presence of a very dense, well-indurated sandstone.

3.4.4.2 Drill Area C

Drill Area C is located approximately 8 to 8.5 miles southeast of Wainwright and approximately 4 miles south and southeast of the LIZ-3 Distant Early Warning (DEW) Station (Figure 3-17). Six boreholes were drilled in this area at elevations ranging from 75 feet to 85 feet. Several large thaw lakes along with swampy terrain are present in the eastern and southeastern part of the drill area. The composite lithologic columns and geophysical logs for these six boreholes are included in Appendix A, Figures 6-11. A brief description of each borehole in Area C follows.

Borehole C-1 was drilled to a total depth of 94.5 feet. Two coal beds in excess of one foot are present, one from 56.9 to 65.4 feet and the other from 80.6 to 82.1 feet. Silty sandy partings (<.1 foot) are present in the lower half of the upper coal bed. The tundra mat is 1.5 to 2.3 feet thick and the Gubik Formation, which consists of silt and sand layers, is 21 feet thick. The Corwin Formation is present below 23 feet and consists of interbedded claystone, carbonaceous shale, shale, siltstone, and coal beds to 70 feet. Sandstone is predominate in the lower 24.5 feet of the borehole.

The upper .8 foot was thawed with massive ice from .8 to 2 feet. The sediments contained visible ice crystals, ice coatings, and random ice formations to 45 feet. Nonvisible-bonded with no excess ice was present to 85 feet with nonvisible-friable ice in the lower 10.5 feet. The geophysical logs show a rapid decline in gamma gamma density below the casing of 24 cps. The natural gamma log reflects the increase in density of the main coal bed by a 10 cps increase. The gamma gamma shows a low density (7 cps change) for the upper 3.5 feet of the upper coal bed and a higher density (by 5 cps) for the lower 5.0 feet of the upper coal bed. Sloughing in the hole prevent opening the calipers or descending deeper than 83 feet.

Borehole C-2 was drilled to a total depth of 89.5 feet. One coal bed is present from 72.0 to 80.4 feet. The coal contains pyrite along fractures. The tundra mat is one foot thick and the Gubik Formation, which consists of greenish-brown silt and sand, is 32 feet thick. The Corwin Formation is present below 33 feet and consists of siltstone, fine grained sandstone (49 feet to 72 feet), pebbly, silty sandstone (36 to 42 feet), and thinly bedded carbonaceous rich siltstone (81 to 89 feet).

The tundra mat was thawed to one foot, with massive ice from one foot to 21.5 feet. The sediments contained visible-random layers of ice, ice crystals, ice coatings on grains, and some visible-stratified ice layers. The geophysical logs indicate a rapid drop in density below the casing with a broad natural gamma peak from 74 to 83 feet.

Borehole C-3 was drilled to a total depth of 97.1 feet. One coal bee is present from 85.1 to 93.1 feet. The coal is fractured, finely laminated, has thin clay partings and contains pyrite along fractures. The tundra mat is .8 feet thick and the Gubik Formation, which consists of silty sand and medium grained sand, is 38 feet thick. The Corwin Formation is present below 39 feet and consists of silty sandstone from 39 to 43 feet, clayey siltstone from 43 to 76 feet and from 80 to 97.1 feet, and sandstone from 76 feet to 80 feet.

The top one foot of the section in this borehole was thawed and graded into massive ice for 2 feet. The sediments contained nonvisible-bonded with no excess ice from 3 feet to the bottom of the borehole with only thin scattered layers of visible, randomly oriented ice layers and nonvisible-friable ice. The geophysical logs indicate a change in density at the contact of the Gubik Formation with the Corwin Formation and a drop in the natural gamma and gamma gamma count at the bottom of the casing (56 feet). A large sloughed area is indicated by the caliper log and is reflected in the natural gamma and gamma gamma logs from 56 to 64 feet. Both the natural gamma and gamma gamma logs show the coal beds as a broad peak with 12 to 15 cps difference.

Borehole C-4 was drilled to a total depth of 98.5 feet. One coal bed is present from 79.0 to 85.4 feet. The coal contained pyrite along fractures, was friable and/or brittle and thinly laminated. The tundra mat is .5 to 1 foot thick and the Gubik Formation, which consists of loose sand, is 41 feet thick. The Corwin Formation is present below 42 feet and consists of silty sandstone from 42 to 50 feet, clayey siltstone from 50 to 65 feet, and silty sandstone from 67 feet to the top of the coal at 79 feet. Siltstone underlies the coal from 85.4 to 98.5 feet.

The uppermost one foot of the borehole was thawed with visible, randomly oriented and stratified ice present in the underlying sediment to 5 feet. Nonvisible-bonded sediments with no excess ice was present from 5 to 90 feet and visible, randomly oriented and stratified ice layers were present from 90 to 98.5 feet. The geophysical logs indicate sloughed areas at 36 feet and from 50 to 62 feet. The gamma gamma log indicates a density decrease below the casing. Both the natural gamma and gamma gamma reflect the presence of the coal bed by changes in the counts per second of 8 and 12 respectively.

Borehole C-5 was drilled to a total depth of 96.5 feet. One coal bed is present between 68.7 and 76.0 feet. The coal is moderately friable and contains a small percentage of pyrite mostly along fracture. The tundra mat is one foot thick and the Gubik Formation, which consists of silt, sand, and a thin seam of gravel, is 31 feet thick. All of the sediment between 12 and 32.2 feet was washed cut when the casing was installed. The Corwin Formation is present below 32 feet and consists predominantly of silty sandstone, sandstone, and coal with thin beds of clayey siltstone (from 58 to 60 feet and from 63 to 65 feet).

The upper 1.5 feet of the borehole was thawed, and sediments containing stratified and massive ice are present to 3.5 feet. The sediment contained nonvisible-bonded with no excess ice in the lower 93 feet. The geophysical logs show a steady decrease in density from the top of the hole to the bottom of the casing. From the bottom of the casing to the total drilled depth of the borehole there is an even greater decrease in the density as the caliper indicates that there are many voids and annular wash-outs. The natural gamma and gamma gamma log shows a 17 cps change as a broad peak at the coal seam.

Borehole C-6 was drilled to a total depth of 90.3 feet. One coal bed is present form 54.2 to 62.0 feet. The coal was friable, had a vitreous luster and contained pyrite along fractures. The tundra mat is 1.5 feet thick and the Gubik Formation, which consists of silty sand, is 24 feet thick. The Corwin Formation is present below 25 feet and consists of siltstone from 25 to 28 feet, silty sandstone from 28 to 31 feet, sandy siltstone from 31 to 39 feet, clayey siltstone from 39 to 54.2 feet, coal from 54.2 to 62.0 feet, sandy siltstone and shale from 62 to 70 feet, sandstone from 70 to 83 feet, and clayey siltstone from 83 to 90.3 feet.

The upper 1.5 feet of the borehole was thawed, followed by massive ice to 8 feet. The sediments contained nonvisible-bonded with no excess ice in the rest of the borehole associated with intermittant layers of visible-stratified ice. The geophysical logs are of poor quality due to a short in the electricl system produced by water in the natural gamma portion of the probe.

3.4.4.3 Drill Araa D

Drill area D is located from 3 to 4.5 miles to the northeast of Wainwright and is bordered on the north by the Sinaruruk River (Figure 3-16). Eight boreholes were drilled at elevations between 25 to 50 feet. Boreholes D-1, D-2, and D-7 were drilled on isolated dry polygonal ground that was surrounded by swampy tundra. The other boreholes were drilled in areas where the ground was hummocky or on polygons that were on broad dry ridges. A brief description of the borehole data follows with the composite lithologic and geophysical logs shown in Appendix A, Figures 12-18.

Borehole D-1 was drilled to a total depth of 97.9 feet. One coal bed in excess of one foot is present from 71.9 to 74.8 feet. The tundra mat is one foot thick and the Gubik Formation, which consists of organic rich silty sand, sandy silt, and sand, is 16 feet thick. The Corwin Formation is present below 17 feet and consists of silty sandstone from 17 to 24 feet, clayey siltstone or silty claystone from 24 to 36 feet, silty sandstone from 36 to 58 feet that grades into clayey siltstone from 58 to 78 feet, and from 78 to 97.9 feet is a moderately-indurated sandstone.

The upper 1.5 feet of the borehole was thawed and underlain by approximately 30 feet of sediment that contained variable ice conditions including nonvisible-bonded with no excess ice, visible-random and stratified ice layers, and massive ice. Sediments containing nonvisible-bonded with no excess ice were present from 30 to 97.9 feet. The geophysical tools were not functioning due to a short in the electrical system; therefore, no logs are available for this borehole.

Borehole D-2 was drilled to a total depth of 96.0 feet. A split coal seam is present from 70.8 to 76.5 feet with the 1.3 foot split occurring at 72.1 feet. The coal is friable and contains pyrite along partings. The tundra mat is two feet thick and the Gubik Formation, which consists of fine grained sand, organic rich, fine grained sand, clayey gravel, and silt is 35 feet thick. The Corwin Formation is present below 37 feet and consists of sandy claystone from 37 to 40 feet, gravelly, silty sandstone from 40 to 42 feet, silty sandstone from 42 to 69 feet, and siltstone from 69 to 96.0 feet.

The upper two feet of the borehole were thawed. Sediments containing nonvisible-bonded with no excess ice was present from 2 feet to the bottom of the borehole. Visible-stratified and random ice layers were frequently associated with the nonvisible ice in the lower 25 feet. The geophysical logs show a steady decrease in the density as the tool moved from inside to outside the casing. A void was present below the asing as indicated by the caliper log with both natural gamma and gamma gamma showing more counts per second. The coal beds show geophysical responses as changes of 5 to 8 cps.

Borehole D-3 was drilled to a total depth of 97.7 feet. Two coal beds are present; one from 40.6 to 42.8 feet and the other from 54.9 to 59.0 feet with a .6 foot split at 55.9 feet and a .5 foot split at 57.2 feet. The tundra mat is one foot thick and the Gubik Formation, which consists of three peat layers in the upper 12 feet interbedded with sandy silt is 22 feet thick. The Corwin Formation underlies the Gubik Formation and consists of sandy claystone, siltstone, and shale to 40 feet, silty sandstone from 40 to 81 feet, and clayey siltstone from 81 to 97,7 feet.

The tundra mat was thawed to one foot with underlying massive ice occurring to 12 feet. The sediments contained nonvisible-bonded with excess ice from 12 to 21 feet. Nonvisible-bonded with no excess ice and minor visible, stratified, or randomly oriented ice layers were present in the sediments from 21 to 97.7 feet. The geophysical equipment was not functioning due to a short in the electrical system, therefore no geophysical logs are available.

Borehole D-4 was drilled to a total depth of 103.2 feet. Two coal beds are present; one from 81.3 to 85.3 feet with a .3 foot siltstone lense at 82.5 feet, and the other coal bed from 96.2 to 98.8 feet. The upper coal bed contains pyrite along partings and is friable. The tundra mat is .8 foot thick and the Gubik Formation, which consists of silty sand, fine to medium grained sand, organic rich silty, gravelly sand, sandy gravel, and gravel layers, is 48 feet thick. The Corwin Formation underlies the Gubik Formation and consists primarily of clayey siltstone or silty claystone with a few thin sandstone beds.

The upper one foot of the borehole was thawed and underlain by massive ice to 6 feet. The sediments contained nonvisible-bonded with no excess ice present from 6 to 49 feet. Below 49 feet the sediments showed nonvisible-bonded with no excess ice associated with visible-stratified and random layers of ice to the bottom of the hole. The geophysical logs show the contact of the Gubik and Corwin Formations by a decrease of the natural gamma count. At the bottom of the casing, the borehole is enlarged from 2.25 inches to 3.0 inches due to sloughing. The coal bed from 81.3 to 85.3 feet shows up on the natural gamma and gamma gamma density logs as changes of 6 to 12 cps, respectively.

Borehole D-5 was drilled to a total depth of 98.9 feet. No coal beds are present in this borehole. The tundra mat is one foot thick and the Gubik Formation, which consists of fine to medium grained sand, one thin layer containing coal fragments, and a thin bed of gravelly silty sand, is 35 feet thick. The Corwin Formation underlies the Gubik Formation and consists of silty sandstone from 36 to 38 feet, sandy silt-stone from 38 to 45 feet, silty sandstone from 45 to 76 feet, siltstone and shale from 76 to 91 feet, and sandstone from 91 to 98.9 feet.

The upper two feet of the borehole were thawed with massive and visible-stratified layers of ice present from the bottom of the thawed zone to a depth of 5 feet. The sediments contained nonvisible-bonded with no excess ice from 5 feet to 77 feet. From 77 to 98.9 feet the ice present was visible-stratified and randomly oriented layers, nonvisible-bonded with no excess ice, and nonvisible bonded friable ice. The geophysical log shows a rapid change at the bottom of the casing and numerous minor fluctuations from the end of the casing to the bottom of the hole.

Borehole D-A6 was drilled to a total depth of 97.3 feet. No coal beds in excess of one foot were encountered. The tundra mat is one foot thick and the Gubik Formation, which consists of sand, carbonaceous fragments, and organic rich, silty sand, is 47 feet thick. The Corwin Formation is present below 48 feet and consists of sandstone and silty sandstone from 48 to 62 feet, and sandy siltstone with intermittent sandstone and claystone layers from 62 to 97.3 feet. Three thin coal beds are present at 51, 70, and 85.5 feet.

The upper one foot of the borehole was thawed, below which was a 3 foot layer of massive ice. The sediments contained interstitial, nonvisible-friable ice from 4 to 33 feet. Nonvisible-bonded with no excess ice was present in the sediments from 33 to 97.3 feet with visible, stratified and randomly oriented ice also present from 83 to 97.3 feet. The geophysical logs show a decrease in density at the bottom of the casing. Changes are also apparent at each of the coal beds of 3 to 5 cps.

Borehole D-7 was drilled to a total depth of 100.0 feet. One coal bed is present from 71.6 to 75.1 feet. The coal is broken, friable and contains pyrite along fractures and partings. The tundra mat is 1.5 feet thick and the Gubik Formation is 62 feet thick. The Gubik Formation I consists of fine to medium grained sand, thin gravel layers, and silty sand. The Corwin Formation underlies the Gubik Formation and consists of sandy siltstone from 63 to 67 feet, gravel from 67 to 68 feet, silty sandstone from 68 to 82 feet, and sandy siltstone from 82 to 100 feet.

The upper 1.5 feet of the borehole was thawed with massive ice underlying the thawed layer to 4 feet. The sediments contained nonvisible-bonded with excess ice present from 4 to 40 feet. Nonvisible-bonded with no excess ice was present in the sediments to 100 feet with visible, stratified and randomly oriented ice layers from 82 to 100 feet. The geophysical logs show a 20 cps change at the bottom of the casing. The caliper log indicates a void in the wall of the borehole from the bottom of the casing (58 feet) to 69 feet. The natural gamma and gamma gamma logs show a change of 7 and 11 cps at the coal bed from 71.6 to 75.1 feet.

Borehole D-A8 was drilled to a total depth of 97.5 feet. No coal beds over one foot in thickness were encountered in this borehole. The tundra mat is one foot thick and the Gubik Formation, which consists of sand, is 28 feet thick. The Corwin Formation is present from 29 feet and consists of silty sandstone from 29 to 55 feet, sandy siltstone from 55 to 97.5 feet with a few thin sandstone interbeds. A thin coal bed is present from 62.0 to 62.6 feet.

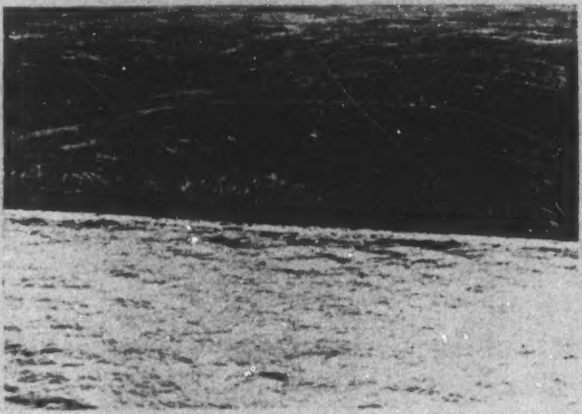
The upper one foot of the borehole was thawed with underlying massive ice from 1 to 6 feet. Sediments ranging between nonvisible-bonded with excess and no excess ice were intermittantly present from 6 feet to 97.5 feet. The geophysical logs show a gradual drop in the density from the top of the hole to the bottom of the casing with only minor fluctuations in the remainder of the borehole.

3.4.5 Regional Correlations and Interpretive Geology

Martin (1980) and Martin and Callahan (1978) have demonstrated that there are many coal beds in the Wainwright area that are laterally continuous (Figure 3-12). Many of the beds outcrop along the steeper banks of the Kuk and Kungok Rivers (Figure 3-18). Attitudes measured from river bank exposures indicate that the Corwin Formation is gently folded (Figure 3-19). Approximately 10 miles south of Wainwright, the Kuk River breaches the axis of an anticline. The anticline becomes less well developed to the north where dips tend to be southerly. Fence diagrams constructed from the borehole data indicate a southerly dip to the Corwin Formation (Figures 3-20a through 3-20d).

Martin (1980) projects the subsurface outcropping of individual coal beds from seismic shot holes 6 to 8 miles to the east of the drill areas and from boreholes 1 to 8 miles to the south. His projections indicate that coal bed number 4 should be at shallow depth in drill area D, coal beds number 5 and 6 should be at shallow depth in drill areas A and B, and that coal bed 8 should be at shallow depth in drill area C.

The borehole data in drill areas A and B indicate the presence of two beds. The upper bed, which is approximately 3 feet thick, probably correlates to Martin's coal bed number 6 and is the uppermost coal bed in Rock Unit 2. This bed is present in all boreholes in this area. The lower bed, which is approximately 7 feet thick, correlates to Martin's coal bed number 5. Martin indicates that this bed is split in the area to the east. Borehole B-3, which is closest to Martin's seismic shot hole line, contains a split bed. Boreholes A-1



Coal seams 11 and 12 in the Corwin Formation exposed along the Kuk River approximately 17 miles south of Wainwright. Clinker to the north, unburned coal to the south. Cliffs are approximately 35 feet high.

PROJECT NO. 80-540 11-81
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FIGURE 3-18 : Coal seams 11 and 12 in the Corwin Formation

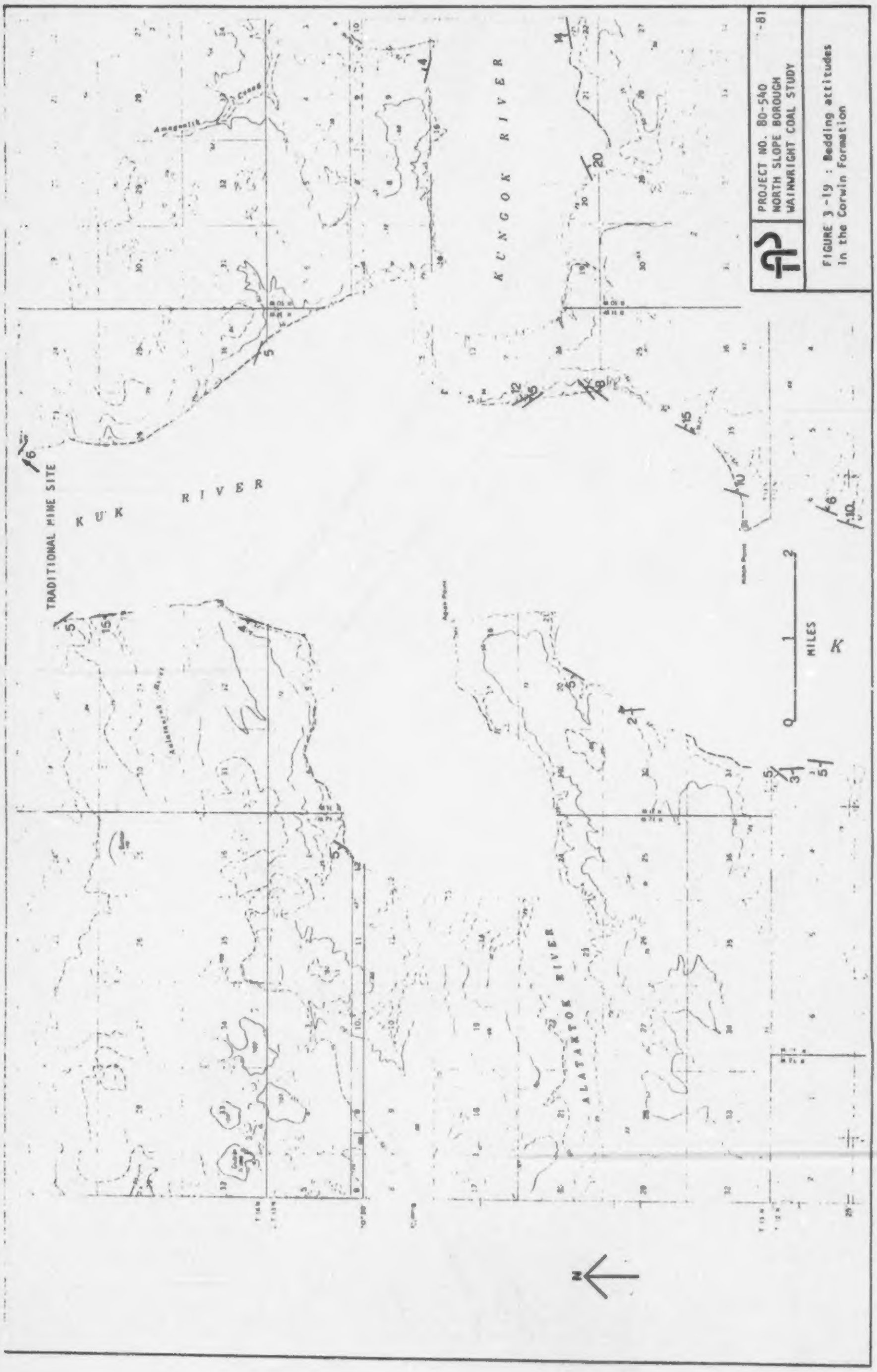
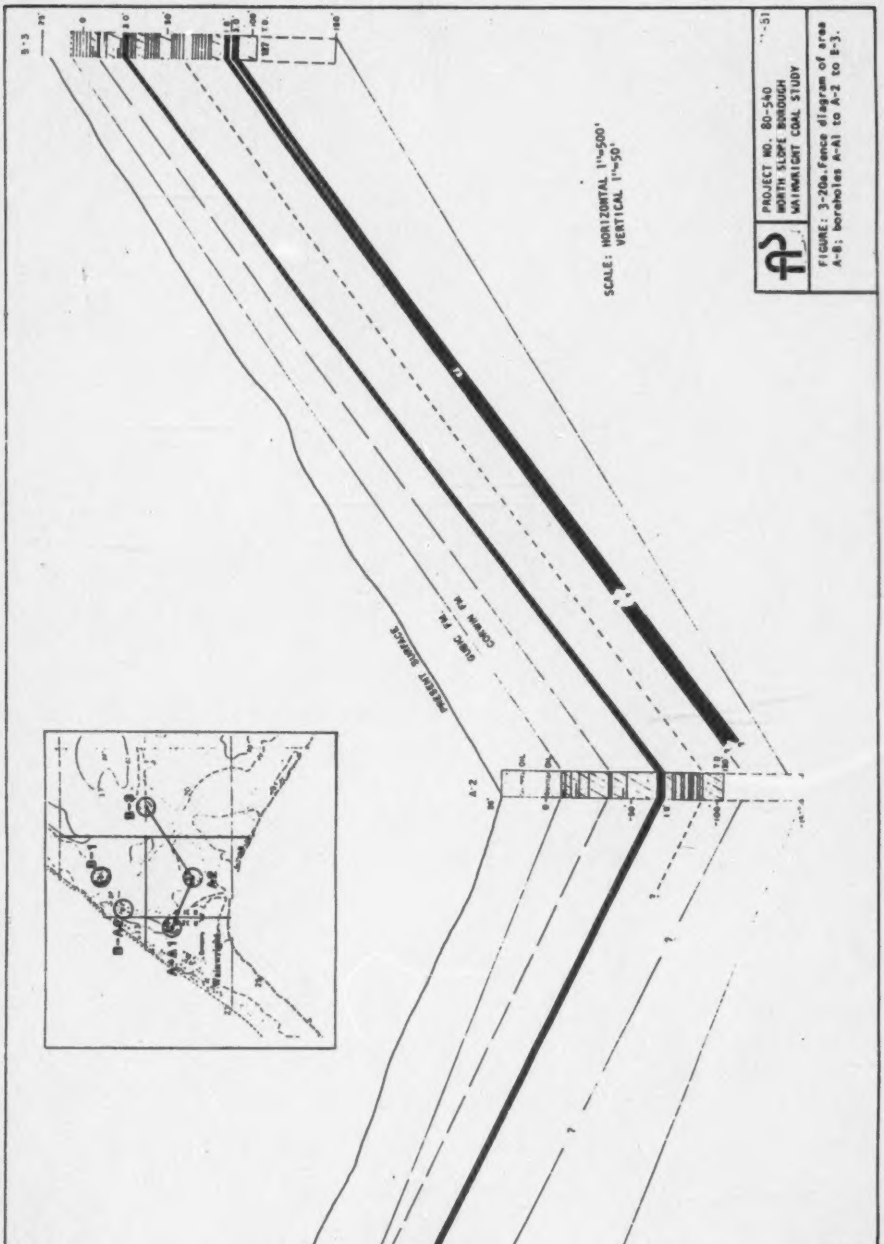
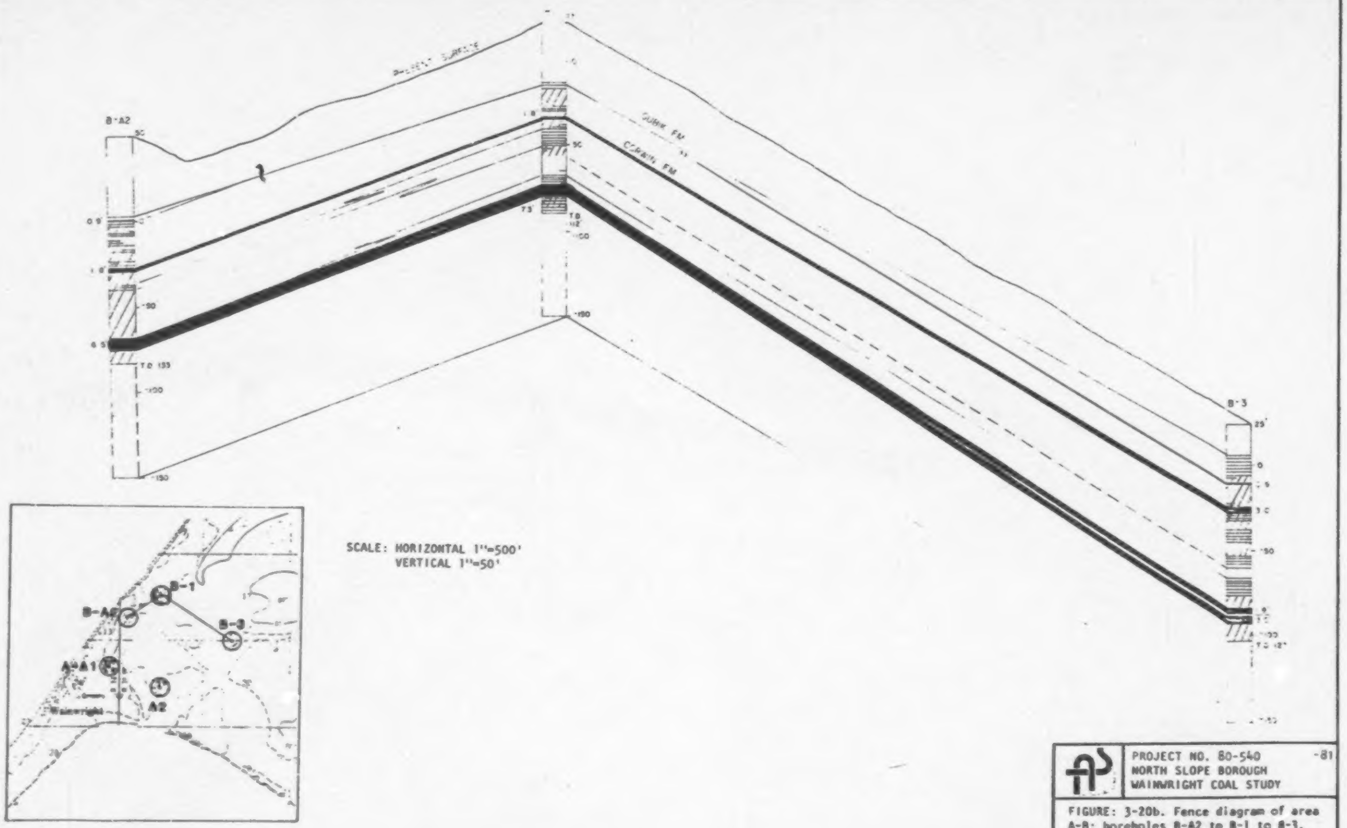

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY
-81
TRADITIONAL MINE SITE
KUK RIVER
KUNGOK RIVER
ALATAKTOK RIVER
Amaguatik Creek
MILES
0
1
2
K
N

FIGURE 3-19 : Bedding attitudes In the Corwin Formation


B-3
A-2
A-A1
PRESENT SURFACE
GUBIC FM.
CORWIN FM.
SCALE: HORIZONTAL 1"=500'
VERTICAL 1"=50'
B-1
B-A2
A-A1
A2
B-3
Wainwright

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

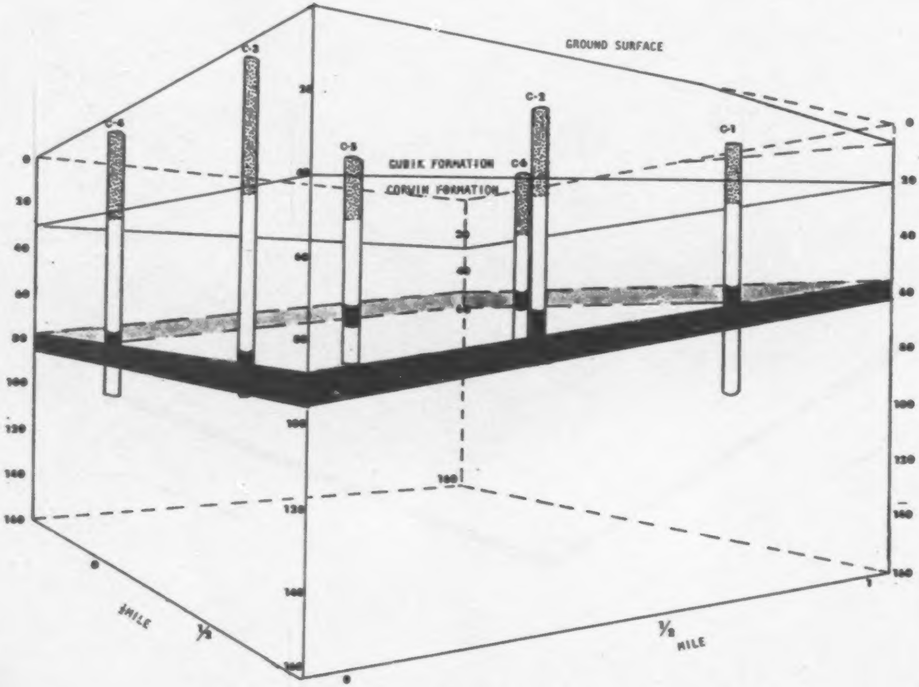
FIGURE: 3-20a. Fence diagram of area A-B; boreholes A-A1 to A-2 to B-3.


B-A2
50
0.9'
1.8'
50
6.5'
T.D. 133
-100
-150
PRESENT SURFACE
1.8'
50
7.3'
T.D. 112'
-100
-150
GUBIK FM
CORWIN FM
B-3
25'
0
3.0
50
-100
T.D. 12'
-150
B-A2
B-1
B-3
A-A1
A2
Wainwright

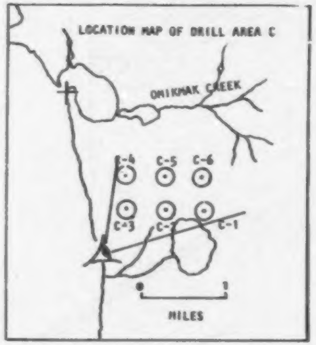
SCALE: HORIZONTAL 1"=500'
VERTICAL 1"=50'

PROJECT NO. 80-540 -81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE: 3-20b. Fence diagram of area A-B; boreholes B-A2 to B-1 to B-3.


GROUND SURFACE
C-4
C-3
C-5
C-2
C-6
C-1
CUBIK FORMATION
CORWIN FORMATION
0
20
40
60
80
100
120
140
160
⅓ MILE
⅓
⅓ MILE
0
1

BOREHOLES ON ⅓ MILE CENTERS
VERTICAL SCALE IN FEET


LOCATION MAP OF DRILL AREA C
ONIKMAK CREEK
C-4
C-5
C-6
C-3
C-2
C-1
0
1
MILES

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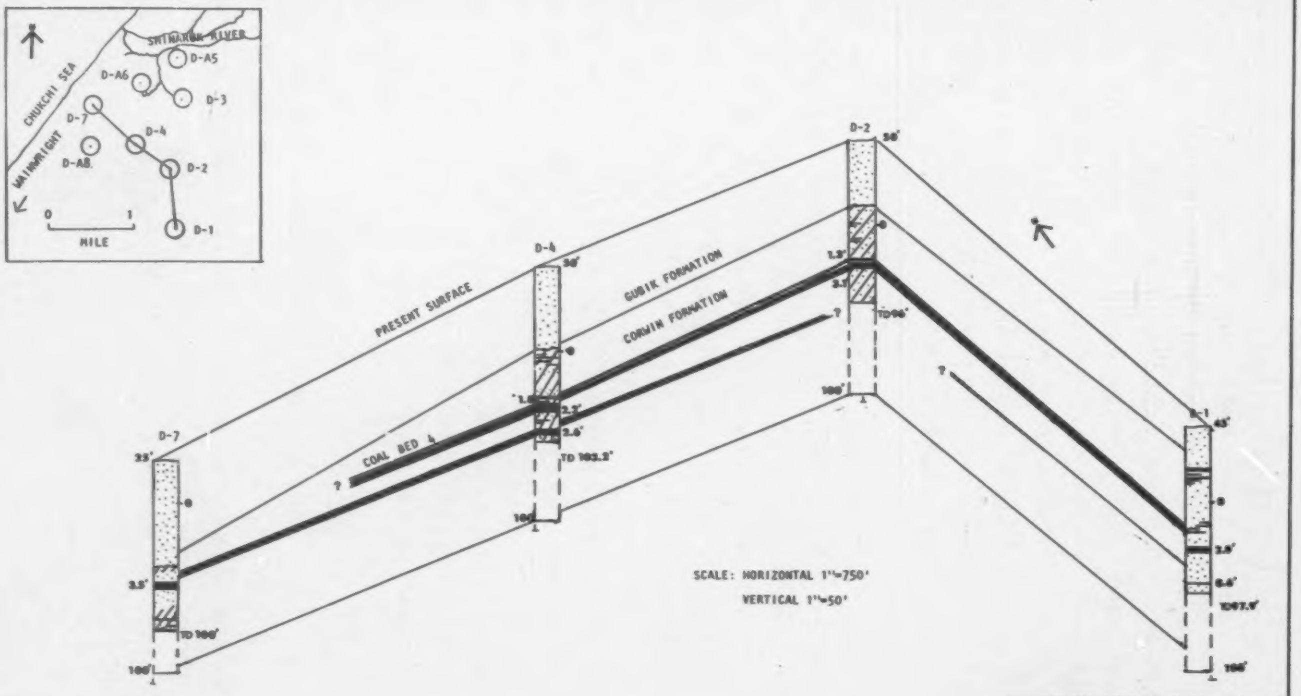
WAINWRIGHT COAL STUDY

FIGURE 3-20c

BLOCK DIAGRAM DRILL AREA C


CHUKCHI SEA
WAINWRIGHT
SHINARUK RIVER
D-A5
D-A6
D-3
D-7
D-4
D-A8
D-2
D-1
0
1
MILE
PRESENT SURFACE
GUBIK FORMATION
CORWIN FORMATION
COAL BED 4
D-7
33'
3.5'
TD 100'
100'
D-4
36'
1.8'
2.2'
2.6'
TD 102.2'
100'
D-2
38'
1.3'
2.1'
TD 96'
100'
D-1
43'
2.9'
6.4'
TD 97.9'
100'
?
SCALE: HORIZONTAL 1"=750'
VERTICAL 1"=50'

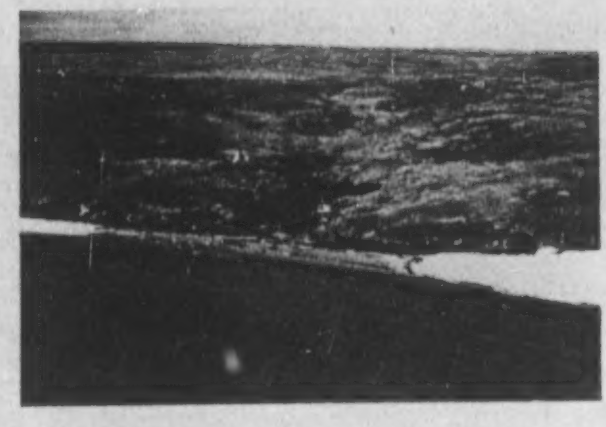
PROJECT NO. 80-540 1-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-20d: Fence diagram for Drill Area D

and A-2 did not intercept this bed. The bed does appear to thicken to the north or northwest which may be the result of the coalescence of the split bed in B-3. Boreholes B-1 and B-A2 did intercept this bed although the split was not present. This lower coal bed (5) appears to be laterally continuous and consistent, maintaining a 6.5 foot to 7 foot thickness over several miles. There does appear to be a slight monoclinal fold trending roughly east-west in these drill areas as indicated by the deepening of the coal bed to the south (Map 2, Area A-B Isopach Map, Chapter 4).

The borehole data in drill area C indicate the presence of one major bed which is over 8 feet thick. This bed appears to be at the stratigraphic position of Martin"s coal bed number 8, Rock Unit 3. All 6 boreholes intercepted this bed which varied very little in thickness. The attitude of the coal bed from the projections indicates a southwesterly dip of 4 to 5 S. Similar attitudes were measured at outcrops along the Kuk River .5 mile to the west-southwest of the drill area (Figure 3-17). Coal from outcrops along the river has been used for many years by the local inhabitants (Figures 3-21). The workings include shallow adits and drifts which have exposed the 8 foot thick bed. Attitudes of N 43 W with dips of 5 to 7 to the south are prevalent.

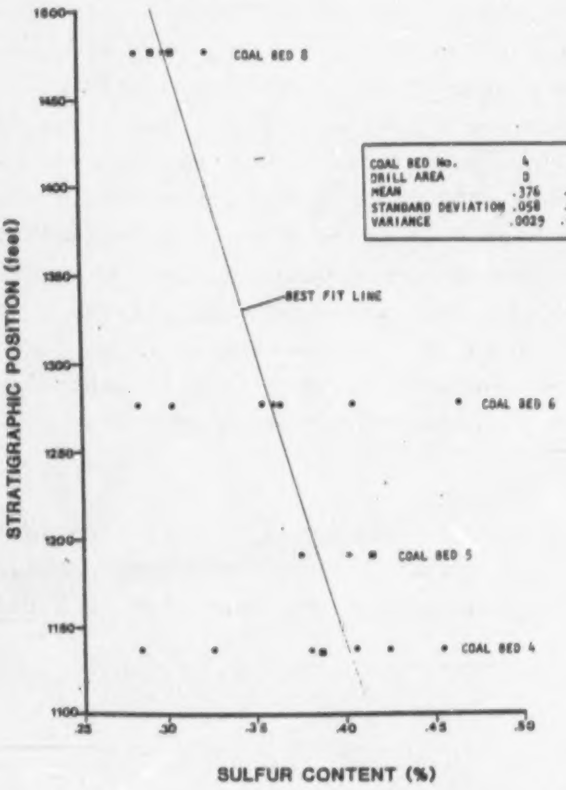
The borehole data in drill area D indicate the presence of two major coal beds. The upper bed appears to be at the stratigraphic position of Martin's coal bed number 4; the lower bed has not been identified by Martin and appears to be laterally discontinuous. There are many partings in the lower bed particularly in borehole D-3. These beds indicate a southerly dip.



PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-21: Traditional mine site to the west-southwest of drill area C

The sedimentary structures and the grain size of the sediment indicates the coal beds in drill areas A, B, and D were formed in a lower delta-plain setting. Delta progradation is from west to east in this area, as indicated by the foreset dips in prodelta sediments. Coal beds associated with this type of sedimentation tend to be thinner, more laterally extensive and have higher, more erratic sulfur content than coal beds formed in upper delta and fluvial flood plains (Martin 1980). Coal beds formed in the upper delta and fluvial flood plains (such as coal bed number 8 of drill area C) tend to have low sulfur content, are often thicker, but lense or intertongue laterally with other sediments. Younger coal beds, in the Wainwright area, which occur higher in the stratigraphic column show a decrease in the mean sulfur content (Figure 3-22). This suggests that reducing conditions were more prevalent during deposition of the older rock units in the sequence. This is consistent with deposition in lower delta plain environments. The decrease in sulfur in units occurring higher in the stratigraphic column is consistent with deposition of progradational sequences of fluvial and upper delta sediments over the older units.



COAL BED No.	4	5	6	8
DRILL AREA	D	B	A&B	C
MEAN	.376	.397	.358	.295
STANDARD DEVIATION	.058	.023	.066	.015
VARIANCE	.0029	.0004	.0036	.0002

- ● Single data point
- ■ Data point where two samples have the same value.
- * Mean value for each coal bed.

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

FIGURE 3-22: Relationship of sulfur content of coal beds to stratigrphic position. Position (feet) is from the base of the Corwin Formation.

3.4.6 Coal Quality Analysis and Rank Determination

Coal rank is defined as the degree of metamorphism to which a coal bed has been subjected. It consists of a natural classification series from lignite to subbituminous to bituminous to anthracite. Generally, the "wet" coal analyses of cores from the Wainwright study area fall within subbituminous C coal category. Four samples, however, yield calorific values (BTU/lb.) in the lignite A rank. Subbituminous C coal is defined as coal having 8300 to 9500 BTU per pound in a moist, mineral-matter-free state. Lignite A coal is defined as coal containing 6300 or more BTU per pound but less than 8300 BTU per pound in a moist, mineral-matter-free state. Overall sulfur content as-received, is generally less than 0.5 percent. Overall ash content (as received) is generally less than 16 percent with as received moistures generally less than 28 percent.

As previously discussed in Section 3.3.1, both individual and composite samples were tested for coal quality. Results of the coal quality analyses program are presented in Tables 3-2 to 3-7.

Drill Areas A-B

Two individual coal seams were analyzed in Drill Area A. The following parameters show ranges of moisture from 23.05 to 24.97 percent; ash contents from 8.61 to 12.25 percent; sulfur content from 0.40 to 0.46 percent and calorific values from 8200 to 8367 BTU per pound (as received).

TABLE 3-2

REPORT OF PROXIMATE ANALYSIS (%)
WAINWRIGHT COAL STUDY

Borehole #	Sample #	Depth Interval (Feet)	Moisture (%)		Ash (%)		Volatile Matter (%)		Fixed Carbon (%)		Calorific Value (Btu/lb)		Sulfur (%)		Mineral Matter Free (Btu/lb)	
			As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry
Area A																
A-A1	A-A1-1-1-3	86.7-89.2	23.05	-	12.25	15.93	28.29	36.77	36.41	47.30	8,200	10,657	0.40	0.51	-	12,884
A-2	A-2-1-1-3	91.8-94.3	24.97	-	8.61	11.47	29.53	39.36	36.89	49.17	8,367	11,152	0.46	0.61	-	12,743
Area B																
B-1	B-1-1-1-3	56.0-57.8	23.37	-	12.57	16.40	27.90	36.40	36.16	47.20	8,067	10,526	0.37	0.48	-	12,805
B-1	B-1-2-1-10	94.9-102.2	24.33	-	3.84	5.07	30.38	40.15	41.45	54.78	9,132	12,067	0.28	0.37	-	12,775
B-A2	B-A2-1-1-2	77.1-78.9	25.59	-	15.63	21.01	26.44	35.53	32.34	43.46	7,226	9,711	0.41	0.56	-	12,575
B-A2	B-A2-2-1-8	117.5-124.1	23.63	-	6.02	7.88	29.95	39.21	40.40	52.91	8,846	11,583	0.30	0.40	-	12,669
B-3	B-3-1-1-3	47.9-51.0	24.18	-	10.22	13.48	29.18	38.49	36.42	48.03	8,328	10,984	0.41	0.53	-	12,868
B-3	B-3-2-1-3	107.8-109.6	24.24	-	7.73	10.20	28.39	37.48	39.64	52.32	8,632	11,394	0.35	0.46	-	12,816
B-3	B-3-3-1-3	112.0-115.0	27.07	-	3.15	4.33	27.08	37.13	42.70	58.54	8,871	12,163	0.36	0.49	-	12,769
Area C																
C-1	C-1-1-1-8	56.9-65.4	27.28	-	4.03	5.54	29.76	40.92	38.83	53.54	8,706	11,971	0.28	0.39	-	12,741
C-2	C-2-1-1-9	72.0-80.4	26.58	-	3.48	4.74	30.27	41.23	39.67	54.03	9,007	12,269	0.32	0.43	-	12,940
C-3	C-3-1-1-9	85.1-93.0	25.04	-	4.0	5.34	29.23	39.41	41.42	55.25	9,111	12,154	0.28	0.37	-	12,906
C-4	C-4-1-1-8	79.1-85.1	25.83	-	3.23	4.36	29.12	39.41	41.71	56.23	9,104	12,275	0.30	0.40	-	12,890
C-5	C-5-1-1-13	67.9-76.0	25.51	-	4.84	6.50	29.34	39.39	40.31	54.11	8,878	11,918	0.30	0.41	-	12,828
C-6	C-6-1-1-8	54.2-62.1	25.60	-	3.24	4.35	29.72	39.95	41.44	55.70	9,064	12,182	0.29	0.39	-	12,791
Area D																
D-1	D-1-1-1-4	71.9-74.8	23.45	-	4.30	5.62	29.34	38.33	42.91	56.05	9,227	12,054	0.45	0.58	-	12,846
D-2	D-2-2-1-3	73.4-76.5	26.04	-	7.12	9.63	28.36	38.35	38.48	52.02	8,448	11,422	0.38	0.51	-	12,759
D-2	D-2-1-1	70.8-72.1	27.76	-	7.79	10.79	-	-	-	-	8,010	11,087	0.40	0.56	-	12,561
D-3	D-3-2-1-5	54.9-59.0	17.08	-	46.54	56.13	17.74	21.39	18.64	22.48	4,229	5,101	0.28	0.34	-	12,972
D-3	D-3-1-1-4	40.6-42.8	23.63	-	2.56	3.36	-	-	-	-	9,467	12,396	0.42	0.56	-	12,875
D-4	D-4-1-1-5	81.3-85.3	22.85	-	8.24	10.68	29.98	38.86	38.93	50.45	8,740	11,329	0.38	0.49	-	12,818
D-A7	D-A7-1-1-6	71.6-75.6	26.70	-	4.23	5.76	28.08	38.31	40.99	55.93	8,794	11,997	0.32	0.44	-	12,803

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY
-81

TABLE 3-2: Proximate analysis &
Wainwright Coal Study

TABLE 3-3

REPORT OF ULTIMATE ANALYSIS (%)
WAINWRIGHT COAL STUDY

Borehole #	Sample #	Depth Interval (Feet)	Moisture (%)		Carbon (%)		Hydrogen (%)		Nitrogen (%)		Sulfur (%)		Ash (%)		Oxygen (Diff.)		Air Drying Loss (%)
			As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	
Area A																	
A-A1	A-A1-1-1-3	86.7-89.2	23.05	-	47.22	61.37	3.22	4.19	1.03	1.34	0.41	0.51	12.25	15.93	12.83	16.66	17.50
A-2	A-2-1-1-3	91.8-94.3	24.97	-	48.81	65.05	3.62	4.83	1.05	1.40	0.46	0.61	8.61	11.47	12.48	16.64	19.67
Area B																	
B-1	B-1-1-1-3	56.0-57.8	23.37	-	46.34	60.48	2.41	3.15	1.04	1.35	0.37	0.48	12.57	16.40	13.90	18.14	17.62
B-1	B-1-2-1-10	94.9-102.2	24.33	-	52.76	69.72	3.45	4.57	1.09	1.44	0.28	0.37	3.84	5.07	14.25	18.83	17.82
B-A2	B-A2-1-1-2	77.1-78.9	25.59	-	42.83	57.55	3.04	4.09	0.87	1.18	0.41	0.56	15.63	21.01	11.63	15.62	20.49
B-A2	B-A2-2-1-8	117.5-124.1	23.63	-	51.75	67.76	3.57	4.68	1.05	1.37	0.30	0.40	6.02	7.88	13.68	17.91	18.18
B-3	B-3-1-1-3	47.9-51.0	24.18	-	48.03	63.35	2.92	3.86	1.01	1.34	0.41	0.53	10.22	13.48	13.23	17.44	18.93
B-3	B-3-2-1-3	107.8-109.6	24.24	-	50.30	66.40	3.45	4.56	1.03	1.36	0.35	0.46	7.73	10.20	12.90	17.02	19.23
B-3	B-3-3-1-3	112.0-115.0	27.07	-	50.17	68.78	3.52	4.83	1.01	1.39	0.36	0.49	3.15	4.33	14.72	20.18	21.93
Area C																	
C-1	C-1-1-1-8	56.9-65.4	27.28	-	50.17	68.99	3.52	4.84	1.09	1.49	0.28	0.39	4.03	5.54	13.63	18.75	23.57
C-2	C-2-1-1-9	72.0-80.4	26.58	-	52.46	71.45	3.71	5.06	1.20	1.64	0.32	0.43	3.48	4.74	12.25	16.68	22.49
C-3	C-3-1-1-9	85.1-93.0	25.04	-	52.60	70.16	3.64	4.85	1.13	1.51	0.28	0.37	4.00	5.34	13.31	17.77	19.77
C-4	C-4-1-1-8	79.1-85.1	25.93	-	52.35	70.58	3.61	4.87	1.20	1.61	0.30	0.40	3.23	4.36	13.48	18.18	21.20
C-5	C-5-1-1-13	67.9-76.0	25.51	-	50.86	68.28	3.69	4.95	1.17	1.57	0.30	0.41	4.84	6.50	13.63	18.29	19.75
C-6	C-6-1-1-8	54.2-62.1	25.60	-	52.10	70.03	3.75	5.04	1.19	1.60	0.29	0.39	3.24	4.35	13.83	18.59	21.34
Area D																	
D-1	D-1-1-1-4	71.9-74.8	23.45	-	53.48	69.87	3.94	5.15	1.02	1.34	0.45	0.58	4.30	5.62	13.36	17.44	17.58
D-2	D-2-2-1-3	73.4-76.5	26.04	-	48.40	65.44	3.59	4.85	1.01	1.36	0.38	0.51	7.12	9.63	13.46	18.21	19.41
D-3	D-3-2-1-5	54.9-59.0	17.08	-	25.46	30.17	2.31	2.79	0.52	0.63	0.28	0.34	46.54	56.13	7.81	9.40	14.92
D-4	D-4-1-1-5	81.3-85.3	22.85	-	50.95	66.04	3.60	4.67	1.02	1.32	0.38	0.49	8.24	10.68	12.96	16.78	16.61
D-A7	D-A7-1-1-6	71.6-75.6	26.70	-	51.16	69.79	3.59	4.90	0.97	1.33	0.32	0.44	4.23	5.76	13.03	17.78	21.43

PROJECT NO. 80-540
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY
[illegible]-81

TABLE 3-3 : Ultimate analysis (%)
of Wainwright Coal

COMPOSITE SAMPLES

COAL QUALITY TEST RESULTS

	AB-10		B-20		C-10		D-10	
	As Received	Dry Basis	As Received	Dry Basis	As Received	Dry Basis	As Received	Dry Basis
PROXIMATE ANALYSIS (%)								
Moisture	24.62	-	25.12	-	26.70	-	24.08	-
Ash	11.49	15.24	4.84	6.46	3.74	5.11	14.95	19.70
Volatile Matter	27.68	36.72	28.05	37.46	29.25	39.90	25.45	33.53
Fixed Carbon	36.21	48.04	41.99	56.08	40.31	54.99	35.52	46.77
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calorific Value (Btu/lb)	7,999	10,612	8,859	11,831	8,741	11,926	7,635	10,058
Sulfur (%)	0.41	0.55	0.32	0.42	0.29	0.40	0.33	0.43
Mineral Matter Free (Btu/lb)	-	12,717	-	12,728	-	12,630	-	12,786
ULTIMATE ANALYSIS (%)								
Moisture	24.62	-	25.12	-	26.70	-	24.08	-
Carbon	46.74	62.01	51.79	69.16	52.17	71.18	44.92	59.17
Hydrogen	3.57	4.74	3.63	4.84	3.73	5.09	3.31	4.36
Nitrogen	0.97	1.29	1.02	1.37	1.24	1.69	0.94	1.23
Chlorine*	-	-	-	-	-	-	-	-
Sulfur	0.41	0.55	0.32	0.42	0.29	0.40	0.33	0.43
Ash	11.49	15.24	4.84	6.46	3.74	5.11	14.95	19.70
Oxygen (difference)	12.20	16.17	13.28	17.75	12.13	16.53	11.47	15.11
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Air Drying Loss (%)	18.82		18.75		21.14		17.84	
Free Swelling Index								
Hardgrove Grindability Index	49.3 @	22.38	45.8 @	23.20	56.2 @	23.47	50.5 @	22.34
Specific Gravity	1.40	1.53	1.36	1.48	1.32	1.43	1.39	1.52
Equilibrium Moisture, %	23.96		24.43		24.66		23.31	
Fusion Temperature of Ash (°F)	Reducing	Oxidizing	Reducing	Oxidizing	Reducing	Oxidizing	Reducing	Oxidizing
Initial Deformation	2008	2210	1950	2150	2070	2340	2120	2200
Softening	2270	2290	2000	2230	2100	2360	2310	2390
Hemispherical	2410	2440	2080	2270	2160	2380	2560	2580
Fluid	2510	2520	2150	2320	2260	2410	2580	2640

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

TABLE 3-4 : Composite samples coal quality test results

TABLE 3-5

ELEMENTAL ANALYSIS OF ASH RESULTS
WAINWRIGHT COAL STUDY

COMPOSITE SAMPLE NO.	AB-10	B-20	C-10	D-10
SiO_2	42.6	39.88	36.26	57.75
Al_2O_3	26.03	15.33	20.60	22.11
TiO_2	1.10	0.78	0.86	0.98
Fe_2O_3	6.14	3.35	4.36	3.93
CaO	3.09	4.64	4.68	1.30
MgO	3.80	6.34	6.70	2.93
Na_2O	4.68	5.03	4.31	4.31
K_2O	2.05	1.05	1.11	3.09
P_2O_5	1.92	1.36	0.98	0.25
SO_3	3.70	8.82	10.01	1.70
Ash Viscosity Calculations[a]				
Base Content, %	22.17	26.72	26.83	16.15
Acid Content, %	77.84	73.29	73.18	83.86
Dolomite Content, %	34.87	53.80	53.79	27.19
Base to Acid Ratio	0.29	0.37	0.37	0.20
Silica to Alumina Ratio	1.62	2.60	1.76	2.61
T_{250} (Temp in °F for 250 poise)	2560	2542	2449	2762
Equivalent Silica Content	76.44	73.57	69.74	87.62
Viscosity From Equivalent Silica (Poise)	432.5	268.9	143.9	3419.9

(a) "Fusibility-Viscosity of Lignite-Type Ash." A.F. Duzy, 1965. "Relationship of Coal-Ash Viscosity to Chemical Composition." W.L. Sage and J.B. McIlroy, 1960.

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

TABLE 3 -5 : Elemental analysis of ash results

FORMS OF SULFUR

Composite Sample Designation	As Received				Dry Basis			
	Total S,%	Pyritic S,%	Organic S,%	Sulfate S,%	Total S,%	Pyritic S,%	Organic S,%	Sulfate S,%
AB-10	0.41	0.03	0.38	0.00	0.55	0.04	0.51	0.00
B-20	0.32	0.02	0.30	0.00	0.42	0.02	0.40	0.00
C-10	0.29	0.01	0.28	0.00	0.40	0.02	0.38	0.00
D-10	0.33	0.03	0.30	0.00	0.43	0.03	0.40	0.00

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

TABLE 3-6 :Forms of sulfer tests

Semi-Quantitative Emission Spectrographic Analysis

Element Found	WW A-2 A-2-1-1-3 91.8-94.3 7/29/81	WW B-1 B-1-1-1-3 56.0-57.8 7/26/81
Fe, %	3	3
Mg, %	3	3
Ca, %	1.5	1.5
Ti, %	0.2	0.3
Mn, ppm	300	300
Ag, ppm	3	5
As, ppm	<200	<200
Au, ppm	<10	<10
B, ppm	>2000	>2000
Ba, ppm	5000	5000
Be, ppm	7	7
Bi, ppm	<10	<10
Cd, ppm	<20	<20
Co, ppm	150	100
Cr, ppm	100	50
Cu, ppm	70	70
La, ppm	150	150
Mo, ppm	30	50
Nb, ppm	20	20
Ni, ppm	200	150
Pb, ppm	<10	50
Sb, ppm	<100	<100
Sc, ppm	100	70
Sn, ppm	20	15
Sr, ppm	2000	2000
V, ppm	200	150
W, ppm	<50	<50
Y, ppm	100	100
Zn, ppm	<200	<200
Zr, ppm	1000	700
Th, ppm	<100	<100
Al, %	15	15
Si, %	20	20
Na, %	>5	>5
K, %	5	5
Ga, ppm	500	300
Ge, ppm	70	50

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

TABLE 3-7: Semi-quantitative emission spectrographic analysis

Seven samples of two coal seams were analyzed in Drill Area B. As-received samples show ranges of moisture from 23.63 to 27.07 percent; ash content from 3.84 to 15.63 percent; sulfur content from 0.28 to 0.41 percent and calorific values from 7226 to 9132 BTU per pound.

Composite sample number AB-10 consists of coal sample splits from coal bed 6 (Martin 1980) in Drill Area A-B and the results of analysis are shown in Tables 3-4, 3-5, and 3-6. Composite sample AB-10 calorific value is reported as 7999 BTU per pound, which is less than the average of reportedindividual BTU contents. This may be the result of excess atmospheric moisture in the sample pulps. This BTU value yields a lignite A rank for the mineable seams. As-received moisture is reported to be 24.62 percent, ash content is 11.49 percent, and sulfur content of 0.41 percent. The forms of sulfur analysis indicate that 0.38 percent is organic sulfur with the remaining 0.03 percent consisting of pyritic sulfur. Free swelling index tests, necessary for boiler feed design purposes, are reported as 0, suggesting there will be no appreciable increase in volume upon crushing. The Hardgrove Grindability Index is defined as the relative grindability of ores and minerals in comparison with standard coal, which is assigned a value of 100, as determined by a miniature ball-ring pulverizer. Composite sample AB-10 has a Hardgrove Grindability Index of 49.3 at 22.83 percent moisture. Equilibrium moisture is reported as 23.96 percent with specific gravity of 1.40. The fusion temperature of ash of sample AB-10 ranges from 2000 F, upon initial deformation, to 2510 F for fluid slag. Results of the elemental analysis of AB-10 ash and emission mass spectroscopy are reported in Tables 3-4 and 3-7.

Composite sample B-20 consists of coal sample splits from coal bed 5 (Martin 1980) in drill area B, and results of analysis are shown in Tables 3-4, 3-5, and 3-6. Composite sample B-20 calorific value is reported as 8859 BTU per pound. This BTU value yields a subbituminous C rank for the mineable seam. As-received moisture is reported to be 25.12 percent, ash content is 4.84 percent and sulfur content is 0.32 percent. The forms of sulfur analysis indicate that 0.30 percent is organic sulfur with the remaining 0.02 percent consisting of pyritic sulfur. The free swelling index test was not conducted on this composite sample. The Hardgrove Grindability Index is reported to be 45.8 at 23.20 percent moisture. Equilibrium moisture is reported as 24.43 percent and specific gravity is 1.36. The fusion temperature of ash of sample B-20 ranges from 1950 F, upon initial deformation, to 2150 F for fluid slag. Results of the elemental analysis of ash for sample B-20 are reported in Table 3-5.

Composite sample C-10 consists of coal sample splits from coal bed 8 (Martin 1980) in drill area C, and the results of analysis are presented in Tables 3-4, 3-5 and 3-6. Composite sample C-10 calorific value is reported as 8741 BTU per pound and yields a subbituminous C rank. As-received moisture is reported to be 26.70 percent, ash content is 3.74 percent and sulfur content is 0.29 percent. The forms of sulfur analysis indicate that 0.28 percent is organic sulfur with the remaining 0.01 percent consists of pyritic sulfur. The free swelling index for composite sample C-10 is reported as 0. The Hardgrove Grindability Index is reported to be 56.2 at 23.47 percent moisture. Equilibrium moisture is reported as 21.14 percent and specific gravity of 1.32. The fusion temperature of ash of sample C-10 ranges from 2070 F, upon initial deformation to 2260 F for fluid slag. Results of the elemental analysis of ash for sample C-10 are reported in Table 3-5.

Composite sample D-10 consists of coal sample splits from coal bed 4 (Martin 1980) in drill area D and results of analysis are shown in Tables 3-4, 3-5, and 3-6. Composite sample D-10 calorific value is reported as 7635 BTU per pound. This BTU value yields a lignite A rank coal. This lower BTU value and higher ash content is due to shaley coal and coal shale partings included as part of the coal seam sample. As received moisture is reported as 24.08 percent, ash content is 14.95 percent and sulfur content is 0.33 percent. The forms of sulfur analysis indicate that 0.30 percent is organic sulfur with the remaining 0.03 percent consisting of pyritic sulfur. The free swelling index test was not conducted. The Hardgrove Grindability Index is reported to be 50.5 at 22.34 percent moisture. Equilibrium moisture is 23.31 and specific gravity of 1.39. The fusion temperature of ash of sample D-10 ranges from 2120 F, upon initial deformation, to 2580 F for fluid slag. Results of the elemental analysis of ash for sample D-10 are reported in Table 3-5.

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APPENDIX A

BORING LOGS WITH GEOPHYSICAL DATA

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

EXPLANATION

▒ TUNDRA MAT

■ COAL
SHALEY COAL/COAL WITH PARTINGS

▨ STATIFIED ICE AND INTERSTITIAL ICE

▓ CLAY/CLAYSTONE

░ SILT/SILTSTONE

▩ SILT & SAND

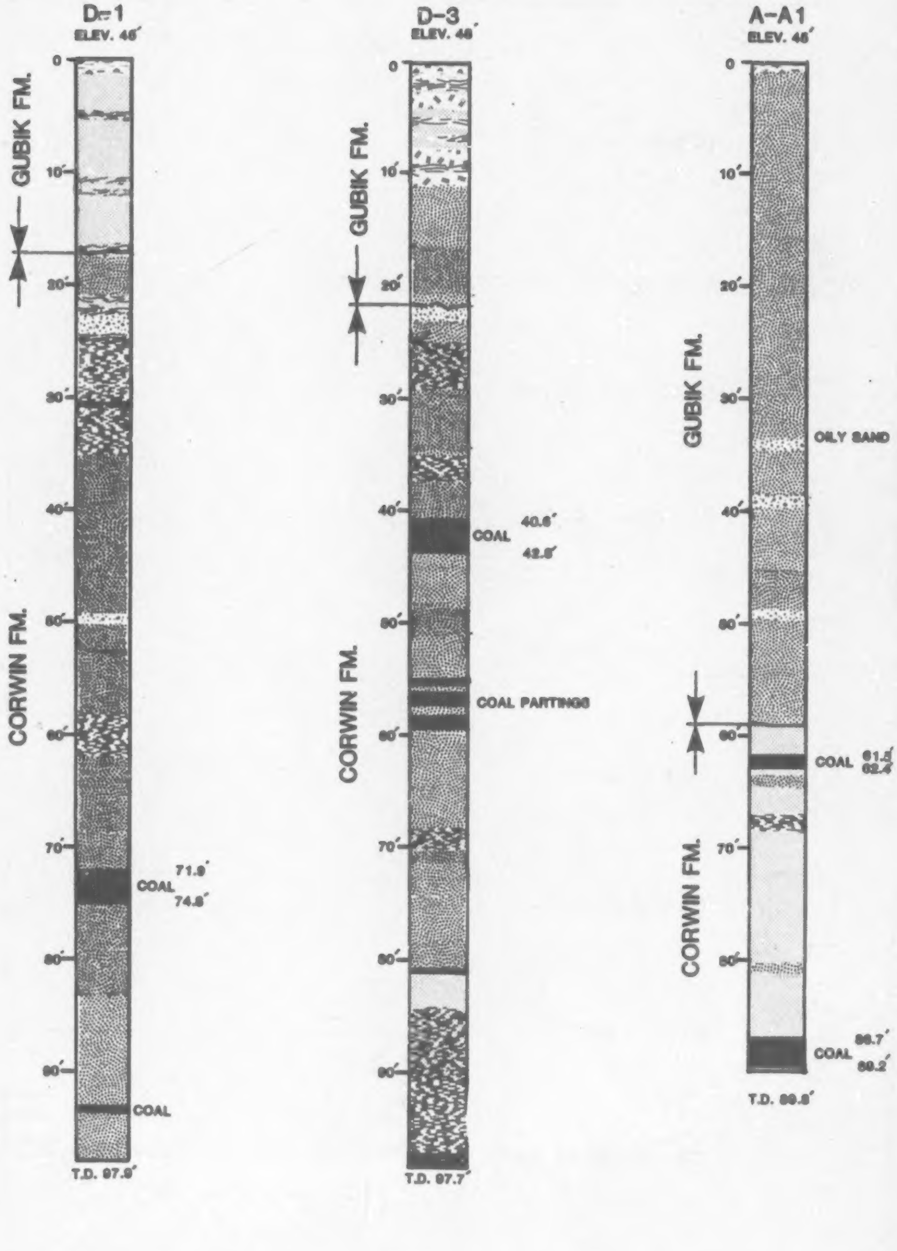
░ SAND/SANDSTONE

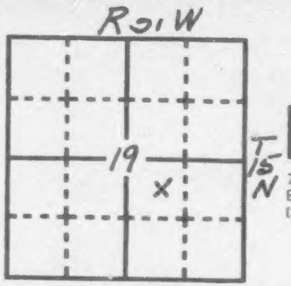
▓ SAND & GRAVEL

▒ GRAVEL WITH SAND

PROJECT NO. 80-540 11-81
NORTH SLOPE BOROUGH
WAINWRIGHT COAL STUDY

APPENDIX A explanation of the composite lithologic logs.


D-1
ELEV. 46'
0
10'
20'
30'
40'
50'
60'
70'
80'
90'
GUBIK FM.
CORWIN FM.
COAL 71.9' 74.9'
COAL
T.D. 97.9'
D-3
ELEV. 46'
0
10'
20'
30'
40'
50'
60'
70'
80'
90'
GUBIK FM.
CORWIN FM.
COAL 40.6' 42.8'
COAL PARTINGS
T.D. 97.7'
A-A1
ELEV. 46'
0
10'
20'
30'
40'
50'
60'
70'
80'
GUBIK FM.
OILY SAND
CORWIN FM.
COAL 61.5' 62.4'
COAL 86.7' 89.2'
T.D. 89.8'



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/30/81

HOLE: WW A-2
Location WAINWRIGHT, ALASKA
Sec: 19 Twp: 15N Rng: 31W
State/County: ALASKA/NORTH SLOPE
Project: WW COAL STUDY
Depth Drilled: 130'
Measured from: GROUND LEVEL
Elevation: ~28'
CLIENT: SID/ERTEC
Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE RAG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	130	126		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor ($x10^{-5}$)	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor (1/4) in. steel	1.573			
Probe Number	1370	1550A		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	2½×½			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

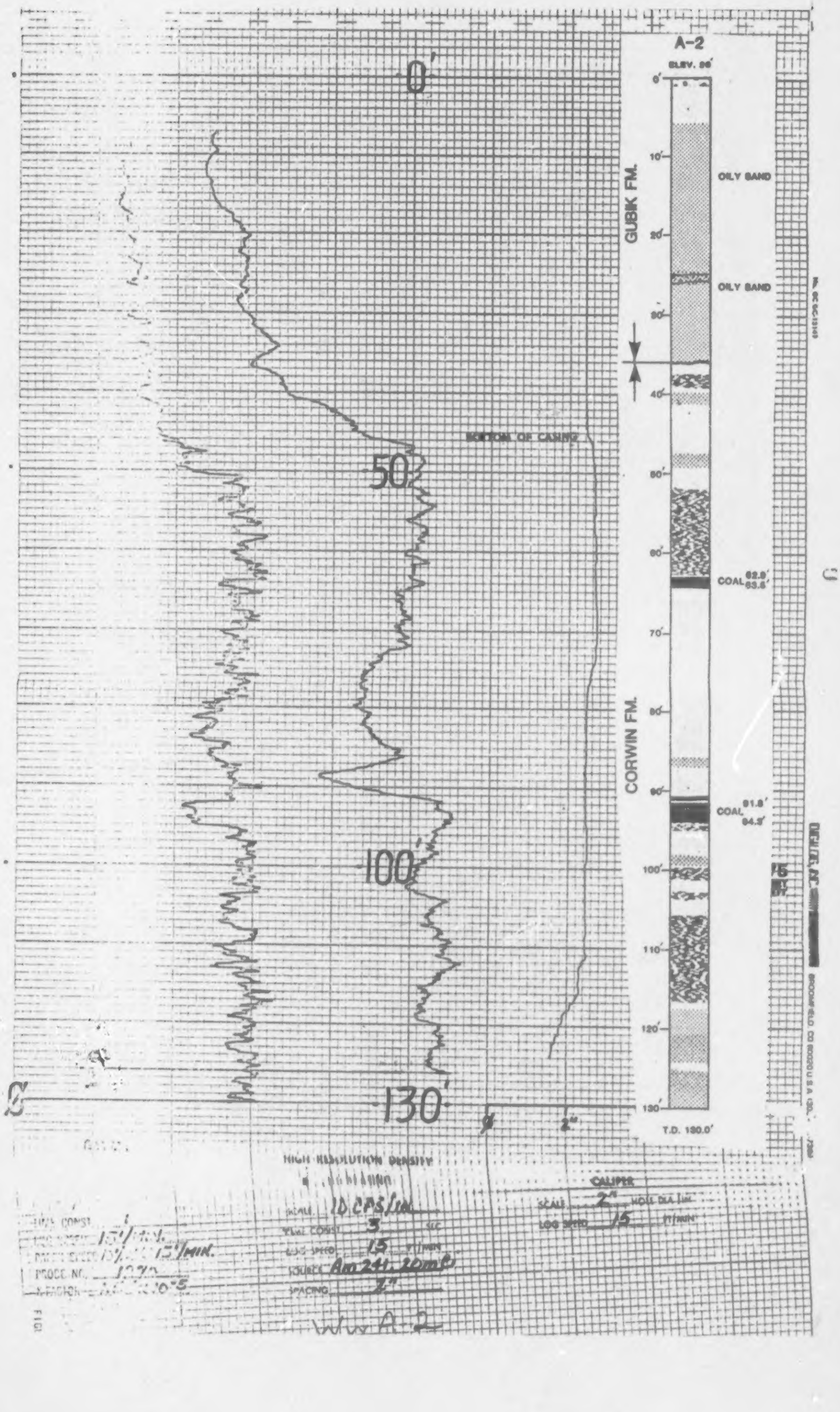
Logged Depth (ft.) 124
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

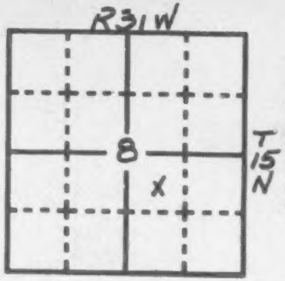
REMARKS:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 130 ft.
Bit Size: in., to ft.
Cased From: 0 to 46' ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.

Other Services Provided:


0'
50'
100'
130'
BOTTOM OF CASING
A-2
ELEV. 36'
GUBIK FM.
CORWIN FM.
OILY SAND
OILY SAND
COAL 62.9' 63.6'
COAL 91.8' 94.3'
T.D. 130.0'
0'
10'
20'
30'
40'
50'
60'
70'
80'
90'
100'
110'
120'
130'
0
2"
GAMMA
HIGH RESOLUTION DENSITY
SCALE 10 CPS/in.
TIME CONST 3 SEC
LOG SPEED 15 FT/MIN
SOURCE Am 241, 20 mC
SPACING 2"
CALIPER
SCALE 2" HOLE DIA./in.
LOG SPEED 15 FT/MIN
TIME CONST
LOG SPEED 15'/min.
PAPER SPEED 15' 15'/MIN.
PROBE NO. 1070
Ww A-2
BROOMFIELD CO 80020 U.S.A.



DIGILOG, INC.
7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/27/81

HOLE: WwB-1
Location WAINWRIGHT, ALASKA
Sec: 8 Twp: 15N Rng: 31W
State/County: ALASKA/NORTH SLOPE
Project: W/W COAL STUDY
Depth Drilled: 112'
Measured from: GROUND LEVEL
Elevation: ~ 23'

CLIENT: S&D/ERTEC
Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE ROG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG	Gamma	Density	Neutron	
Logged Depth (ft.)	112'	108'		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10^{-5})	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor ([illegible] in. steel	1.573			
Probe Number	1270	1551A		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	2½ x ½			
Print Out (ft.)				
Reference Source (cps.)				

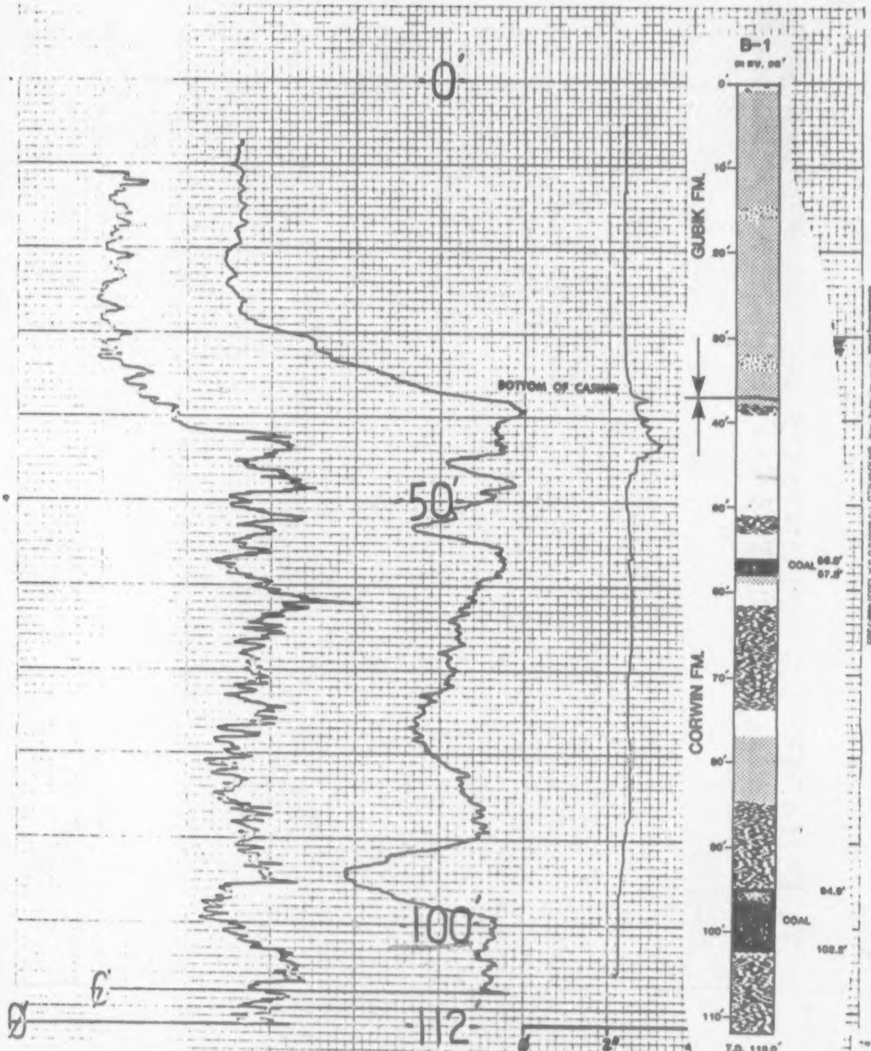
ELECTRIC LOG	
Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG
Logged Depth (ft.) 106'
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

CASING-HOLE DATA
Bit Size: 2.375 in., 0 to 112' ft.
Bit Size: in., to ft.
Cased From: to ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: 0 to 37' ft.
Dia. (inside): in., wall size in.

Other Services Provided:



GAMMA

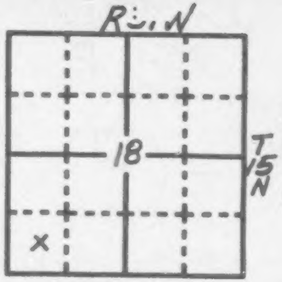
RANGE 10CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN.
PROBE NO. 1.25"
K-FACTOR

HIGH RESOLUTION DENSITY
← INCREASING
SCALE 10 CPS/IN
TIME CONST 3 SEC
LOG SPEED 15 FT/MIN
SOURCE Am 241, 20mCi
SPACING 2"

CALIPER
SCALE 2" HOLE DIA/IN
LOG SPEED 15 FT/MIN

HOLE NO W.W B-1
DATE 7/27/81
DEPTH SCALE 10 FT/IN

FIGURE 3



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/31/81

HOLE: Ww B-A2

Location WAINWRIGHT, ALASKA
Sec: 18 Twp: 15N Rng: 31W
State/County: ALASKA/NORTH SLOPE
Project: Ww COAL STUDY
Depth Drilled: 133'
Measured from: GROUND LEVEL
Elevation: ~ 30'

CLIENT: S&D/ERTEC

Drilling Co. SALISBURY & DIETZ
Geologist: STEVE ROG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	133	129		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant(sec.)	1	3		
Dead Time (µsec.)				
K-factor (x10⁻⁵)	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor (1/4 in. steel	1.573			
Probe Number	1270	[illegible]		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	2½×½			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

Logged Depth (ft.) 127
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

Other Services Provided:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 133 ft.
Bit Size: in., to ft.
Cased From: 0 to 51' ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.

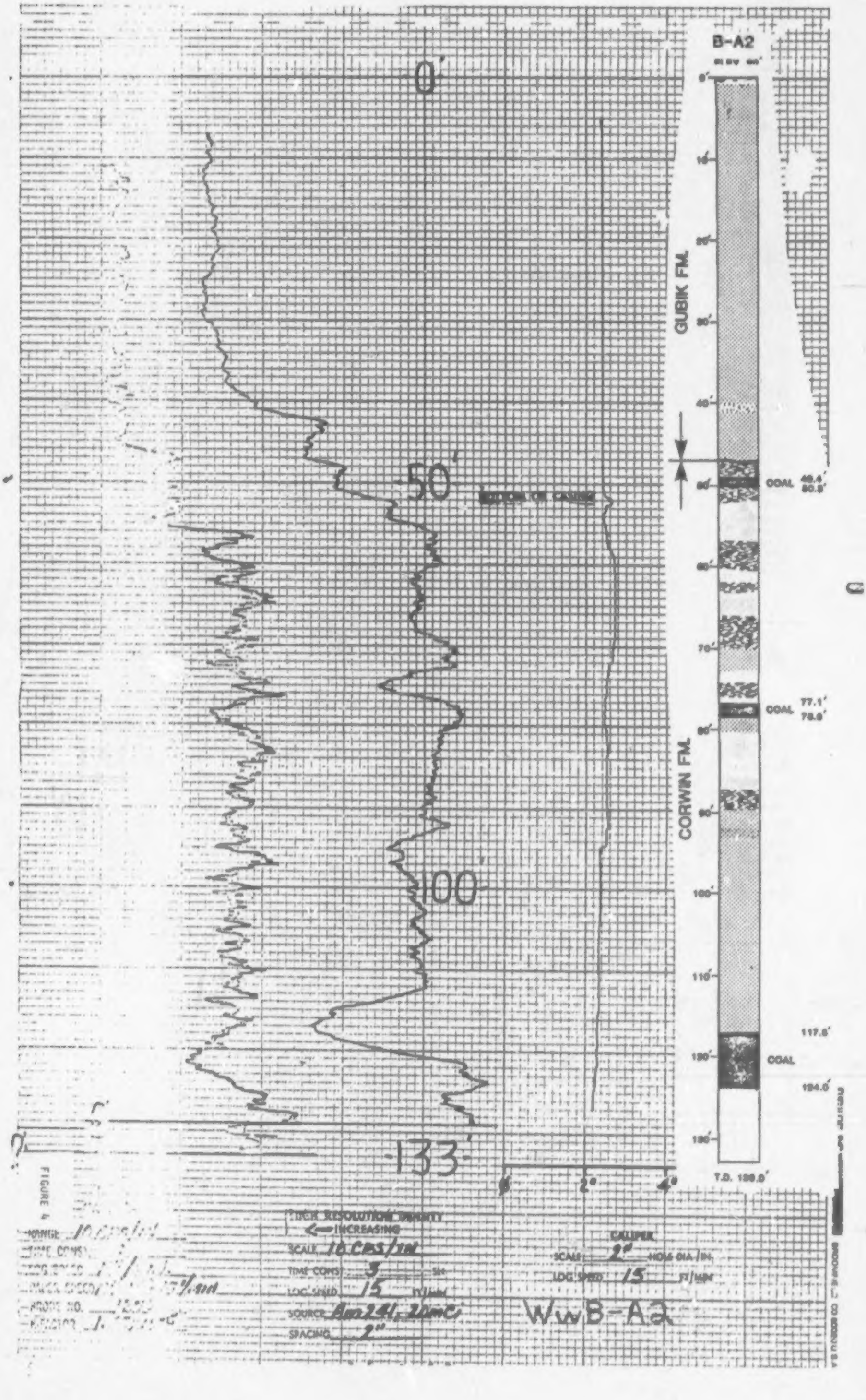
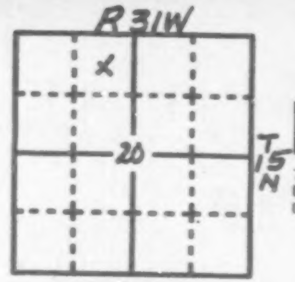

0'
50'
100'
133'
BOTTOM OF CASING
B-A2
0'
10'
20'
30'
40'
50'
60'
70'
80'
90'
100'
110'
120'
130'
GUBIK FM.
CORWIN FM.
COAL 49.4' 50.3'
COAL 77.1' 78.9'
117.5'
COAL
124.0'
T.D. 133.0'
0
2"
4"
RANGE 10 CPS/IN
TIME CONST.
LOG SPEED
CHART SPEED
PROBE NO.
OPERATOR
HIGH RESOLUTION DENSITY
<— INCREASING
SCALE 10 CPS/IN
TIME CONST 3 SEC
LOG SPEED 15 FT/MIN
SOURCE Am241, 20mC
SPACING 2"
CALIPER
SCALE 2" HOLE DIA./IN.
LOG SPEED 15 FT/MIN
WwB-A2

FIGURE 4



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303)466-7388

Date 7/28/81

HOLE: Ww B-3
Location WAINWRIGHT, ALASKA
Sec: 20 Twp: 15N Rng: 31W
State/County: ALASKA/NORTH SLOPE
Project: WW COAL STUDY
Depth Drilled: 126.8'
Measured from: GROUND LEVEL
Elevation: ~ 25'
CLIENT: S&D/ERTEC
Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE ROE/KIM [illegible]
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 6401

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	126	122		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10⁻⁵)	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor ([illegible] in. steel	1.573			
Probe Number	1270	1SDM		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	[illegible]			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

Logged Depth (ft.) 120'
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

Other Services Provided:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 126.8 ft.
Bit Size: in., to ft.
Cased From: 0 to 34' ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.

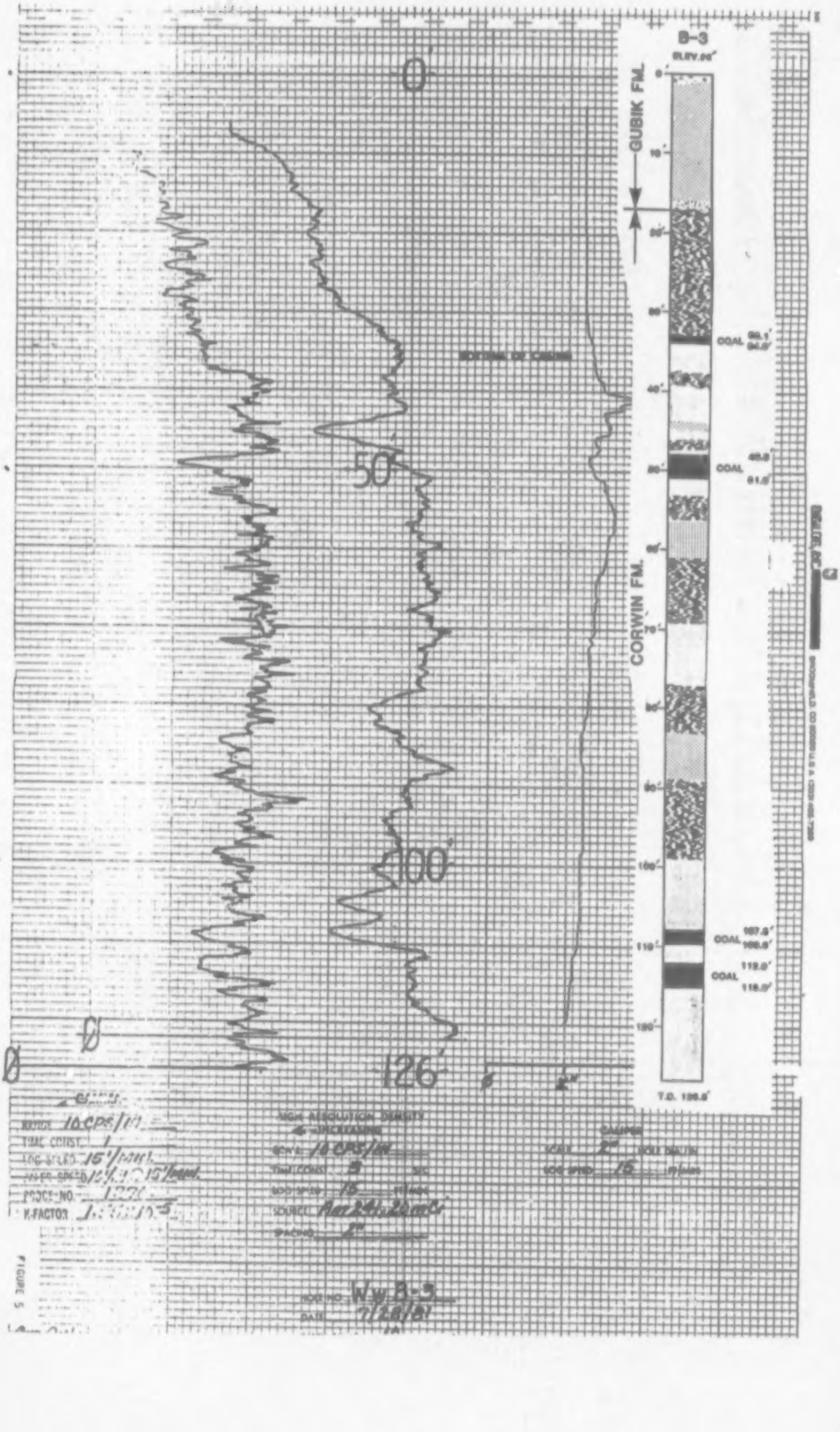
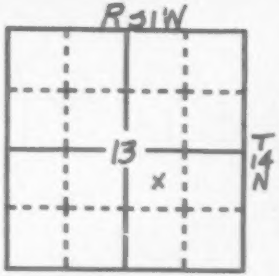

0'
50'
100'
126'
BOTTOM OF CASING
B-3
ELEV. 90'
GUBIK FM.
CORWIN FM.
COAL 33.1' 34.0'
COAL 48.9' 51.0'
COAL 107.0' 109.0'
COAL 112.0' 116.0'
T.D. 126.0'
RANGE 10 CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN.
PROCE NO.
K-FACTOR
HIGH RESOLUTION DENSITY
INCREASING
SCALE 10 CPS/IN
TIME CONST 3 SEC
LOG SPEED 15 ft/min
SOURCE Am 241, 20 mCi
SPACING 2"
CALIPER
SCALE 2" HOLE DIA/IN
LOG SPD 15 m/min
LOG NO. Ww B-3
DATE 7/28/81

FIGURE 5



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/8/81

HOLE: Ww C-1

Location WAINWRIGHT / ALASKA

Sec: 13 Twp: 14N Rng: 31W

State/County: ALASKA/NORTH SLOPE BOR.

Project: WW COAL STUDY

Depth Drilled: 94.5

Measured from: GROUND LEVEL

Elevation: 75'

CLIENT: ERTEC

Drilling Co.: SALISBURY & DIETZ

Geologist: STEVE RAG/KIM MARCUS

Unit Operator: C. DAVIS

Unit Number: T-3

Job Number: 64.01

RADIATION LOG	Gamma	Density	Neutron	
Logged Depth (ft.)	83	79		
Rerun Interval (ft.)				
Range (cps./in.)	30	10A		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	2	2		
Dead Time (μsec.)				
K-factor (x10⁵)				
Water Factor ( ) in. hole	1.04			
Casing Factor ( ) in. steel				
Probe Number	1270	1556A		
Probe Dia. (in.)	1¼			
Crystal Size (in.)	2½x5½			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG	
Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

LOG

Logged Depth (ft.)

Scale:

Depth Scale (ft./in.)

Logging Speed (ft./min.)

REMARKS: DID NOT RUN CALIPER - DUE TO POOR HOLE CONDITIONS.

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 94.5 ft.

Bit Size: in., to ft.

Cased From: 0 to 37 ft.

Dia. (inside): 2.385 in., wall size 1/4 in.

Cased From: to ft.

Dia. (inside): in., wall size in.

Other Services Provided:

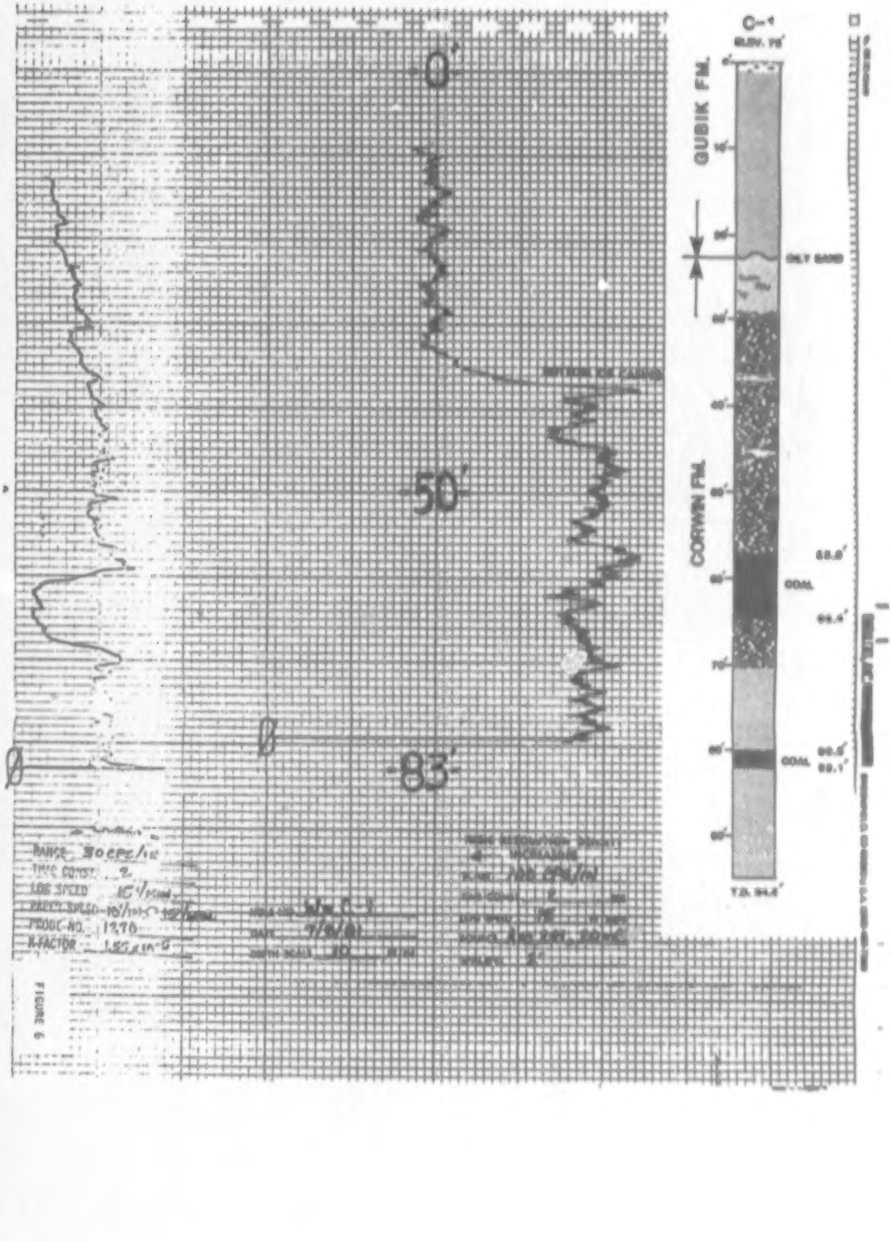
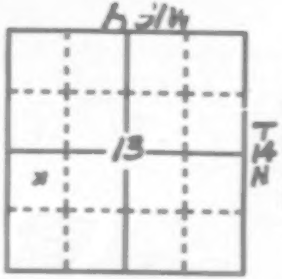

0'
50'
83'
C-1
GUBIK FM.
SILTY SAND
CORWIN FM.
COAL
COAL
T.D. 94.4'
BOTTOM OF CASING
RANGE 30 cpc/in
TIME CONST. 2
LOG SPEED 10'/min
PROBE NO. 1270
DATE 7/8/81

FIGURE 6



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/9/81

HOLE: Ww C-2
Location WAINWRIGHT, ALASKA
Sec: 13 Twp: 14N Rng: 31W
State/County: ALASKA/NORTH SLOPE BR.
Project: Ww COAL STUDY
Depth Drilled: 89'
Measured from: GROUND LEVEL
Elevation: 85'

CLIENT: ERTEC
Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE RDG./KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	89	85		
Rerun Interval (ft.)		[illegible]		
Range (cps./in.)	[illegible]	[illegible]		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	2	2		
Dead Time (μsec.)				
K-factor (x10⁵)	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor ( ) in. steel				
Probe Number	1270	1590A		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	[illegible]			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

Logged Depth (ft.) 83
Scale: 2 in Hole DIA./in
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

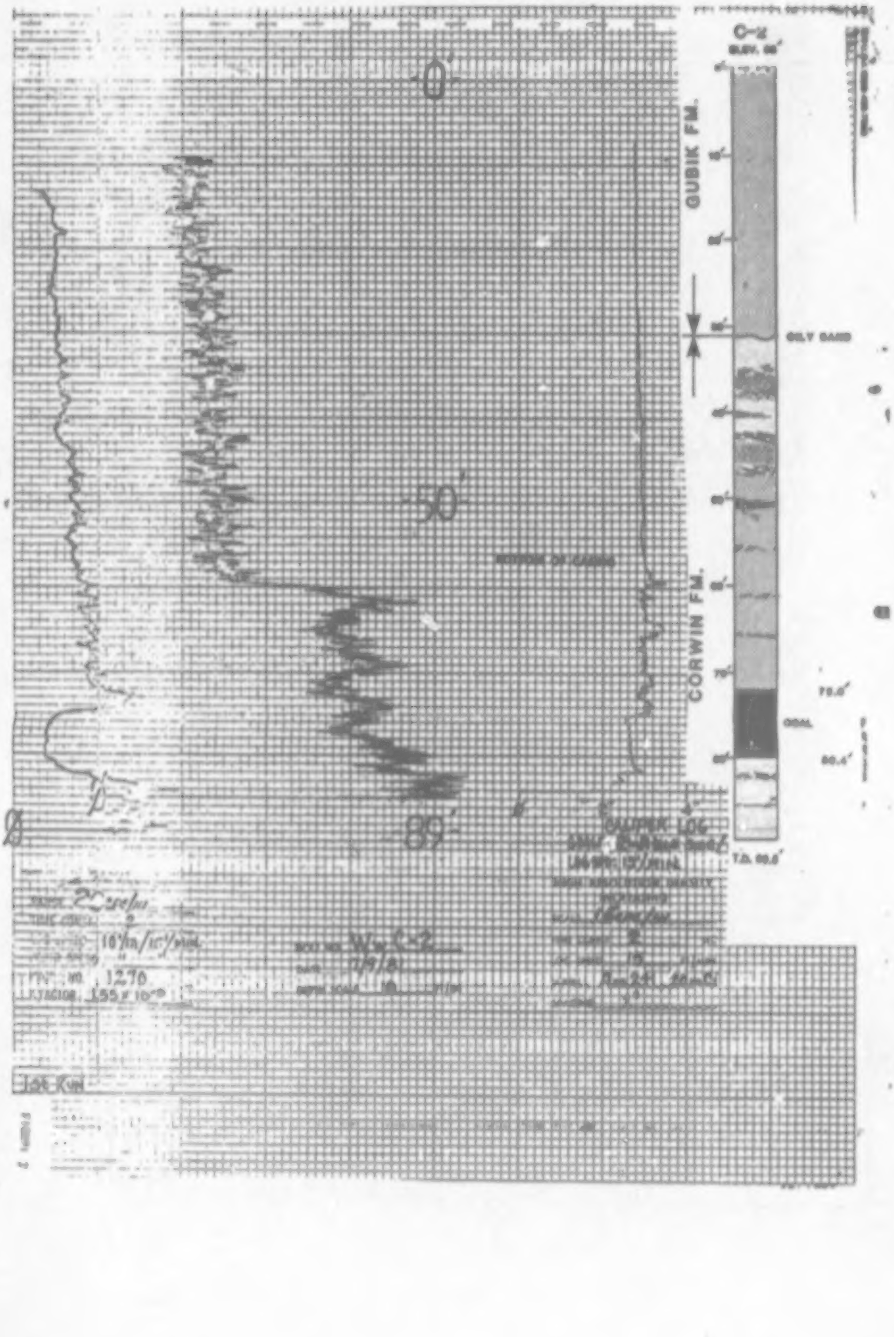
REMARKS: NOISY DENSITY DUE TO INSUFFICIENT UNIT WARM UP TIME – HOLE HAD TO BE LOGGED QUICKLY BECAUSE OF INTERNAL DEGRADATION.

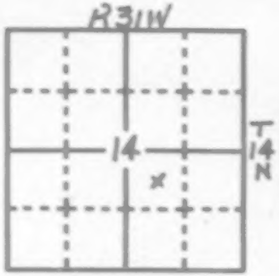
2ND COPY = BEST RUN BUT BOTTOM OF HOLE CAVED IN.

Other Services Provided:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 89' ft.
Bit Size: in., to ft.
Cased From: 0 to 58 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.


0'
50'
89'
BOTTOM OF CASING
GUBIK FM.
CORWIN FM.
C-2
SILTY SAND
COAL
CALIPER LOG
LOG SPD. 15'/MIN.
HOLE NO. W-C-2
1270
155 x 10⁻⁶
10'/in/10'/min
2
15
T.D.



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/11/81

HOLE: Ww C-3

Location WAINWRIGHT, ALASKA
Sec: 14 Twp: 14N Rng: 31W
State/County: ALASKA/NORTH SLOPE BOR
Project: Ww COAL STUDY
Depth Drilled: 97.1'
Measured from: GROUND LEVEL
Elevation: 85'

CLIENT: ERTEC

Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE RIG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	97	93		
Rerun Interval (ft.)				
Range (cps./in.)	15	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10^5)	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor ( ) in. steel	'			
Probe Number	1270	1530A		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	2½x½			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

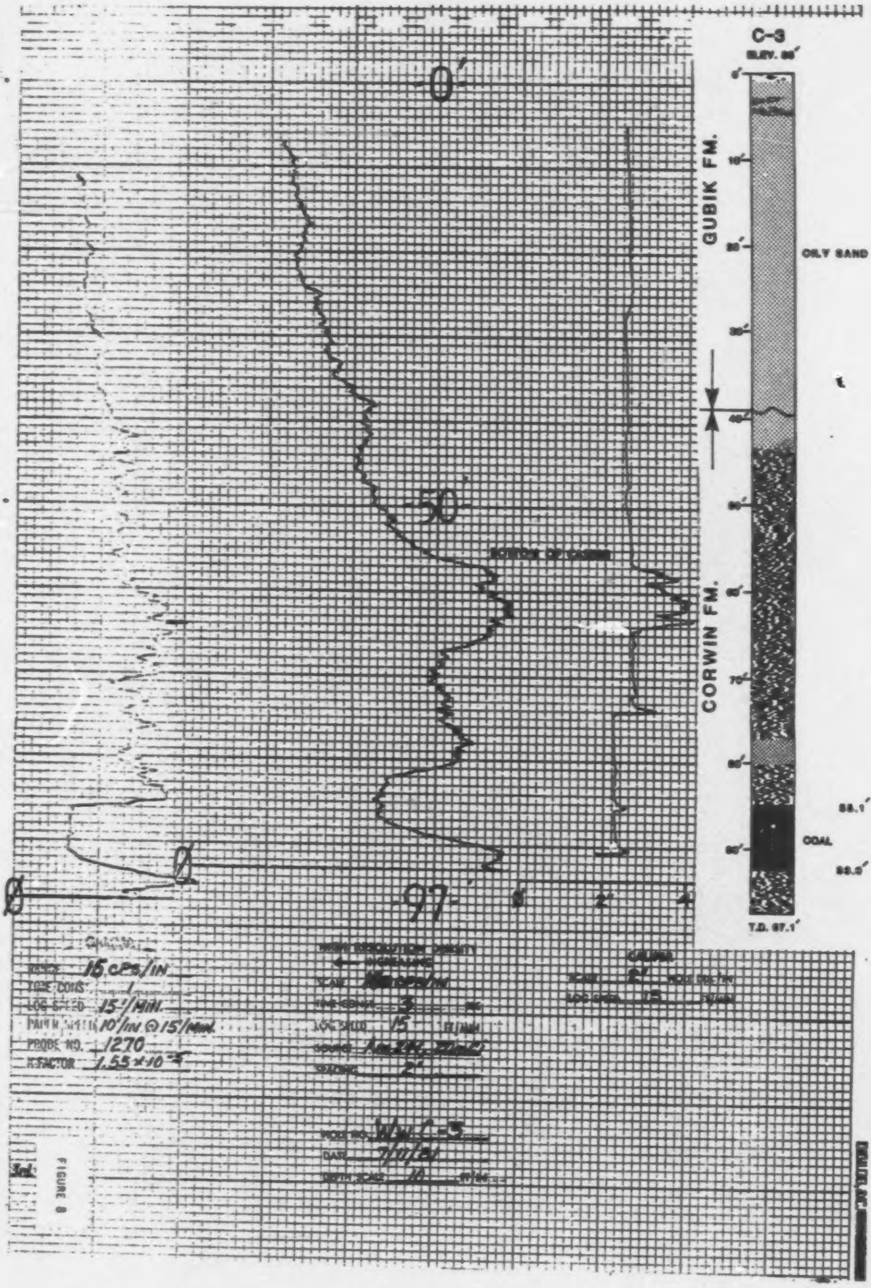
Logged Depth (ft.) 91
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

Other Services Provided:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 97' ft.
Bit Size: in., to ft.
Cased From: 0 to 56 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.



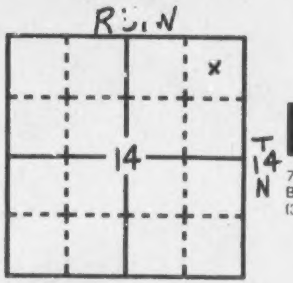
GAMMA
SCALE 15 CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN.
PAPER SPEED 10'/IN @ 15'/MIN.
PROBE NO. 1270
K-FACTOR 1.55×10^-5

HIGH RESOLUTION DENSITY
← INCREASING
TIME CONST. 3 SEC
LOG SPEED 15 FT/MIN
SPACING 2'

CALIPER
SCALE 2" HOLE DIA/IN
LOG SPEED 15 FT/MIN

HOLE NO. WW C-3
DATE 7/10/81
DEPTH SCALE 10 FT/IN

FIGURE 8



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/12/81

HOLE: Ww C-4

Location WAINWRIGHT, ALASKA
Sec: 14 Twp: 14N Rng: 31W
State/County: ALASKA/NORTH SLOPE BOR.
Project: Ww COAL STUDY
Depth Drilled: 98.5
Measured from: GROUND LEVEL
Elevation: 85'

CLIENT: SID / ERTEC

Drilling Co.: SAUSBURY & DIETZ
Geologist: STEVE ROG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	98	94		
Rerun Interval (ft.)				
Range (cps./in.)	20	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10^{-5})	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor ( ) in. steel				
Probe Number	1270	1550A		
Probe Dia. (in.)	1¼			
Crystal Size (in.)	2½×½			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

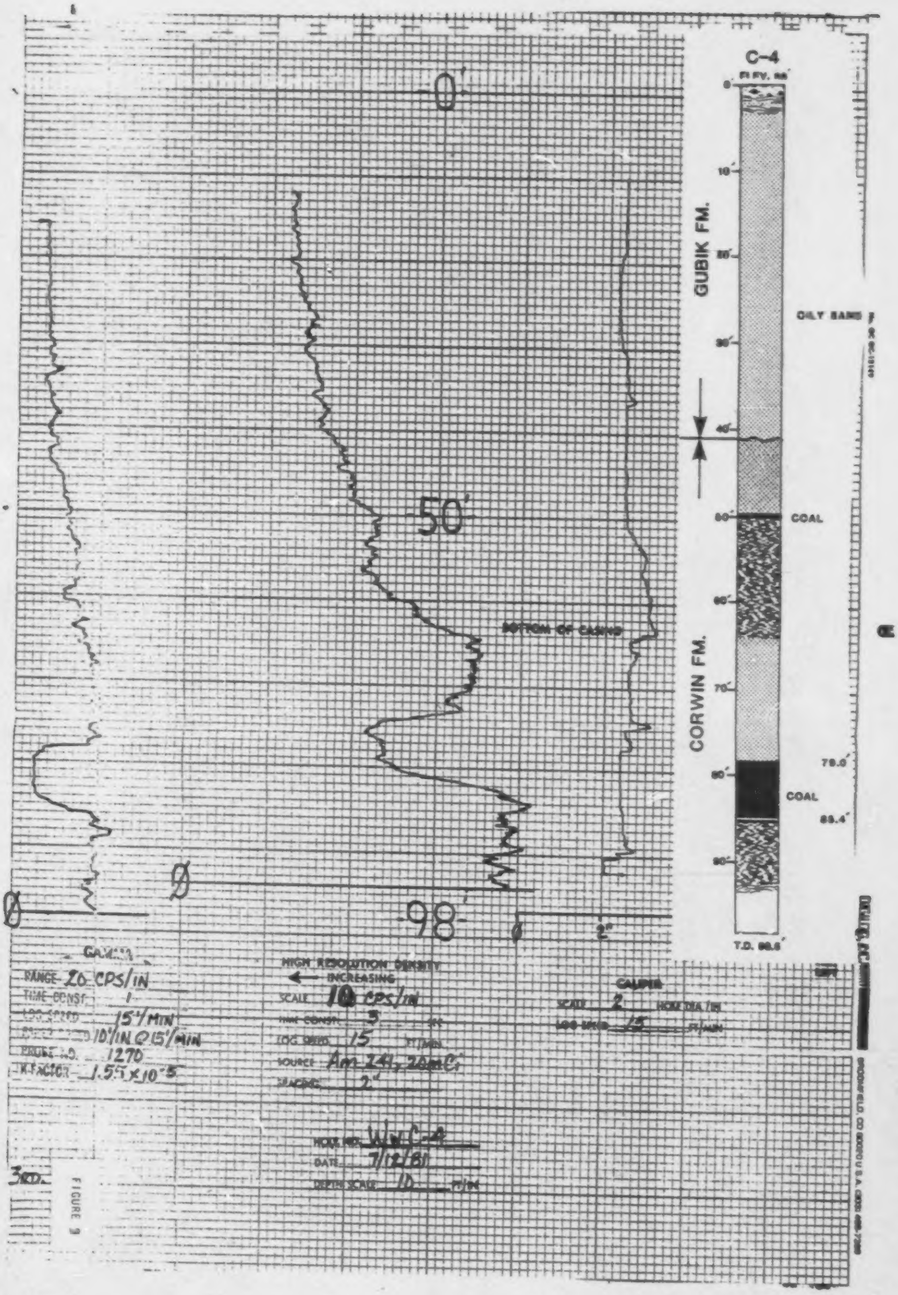
Logged Depth (ft.) 92
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

Other Services Provided:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 98 ft.
Bit Size: in., to ft.
Cased From: 0 to 62 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.



GAMMA
RANGE 20 CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN
CHART SPEED 10'/IN @ 15'/MIN
PROBE NO. 1270
K FACTOR 1.55 x 10^-5

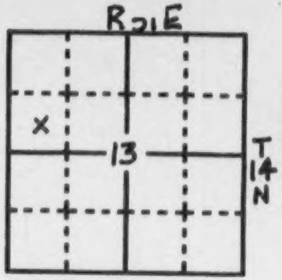
HIGH RESOLUTION DENSITY
← INCREASING
SCALE 10 CPS/IN
TIME CONST. 3 SEC
LOG SPEED 15 FT/MIN
SOURCE Am 241, 20mCi
SPACING 2"

CALIPER
SCALE 2 HOLE DIA/IN
LOG SPEED 15 FT/MIN

HOLE NO. Ww C-4
DATE 7/12/81
DEPTH SCALE 10 FT/IN

3RD.

FIGURE 9



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/13/81

HOLE: WwC-5
Location WAINWRIGHT, ALASKA
Sec: 13 Twp: 14N Rng: 31E
State/County: ALASKA/NORTH SLOPE
Project: WW COAL STUDY
Depth Drilled: 96.5'
Measured from: GROUND LEVEL
Elevation:
CLIENT: S&D / ERTEC
Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE RDG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG	Gamma	Density	Neutron	
Logged Depth (ft.)	96	92		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant(sec.)	1	3		
Dead Time (µsec.)				
K-factor (x10⁻⁵)	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor ( ) in. steel				
Probe Number	1270	1550A		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	2½x½			
Print Out (ft.)				
Reference Source (cps.)				

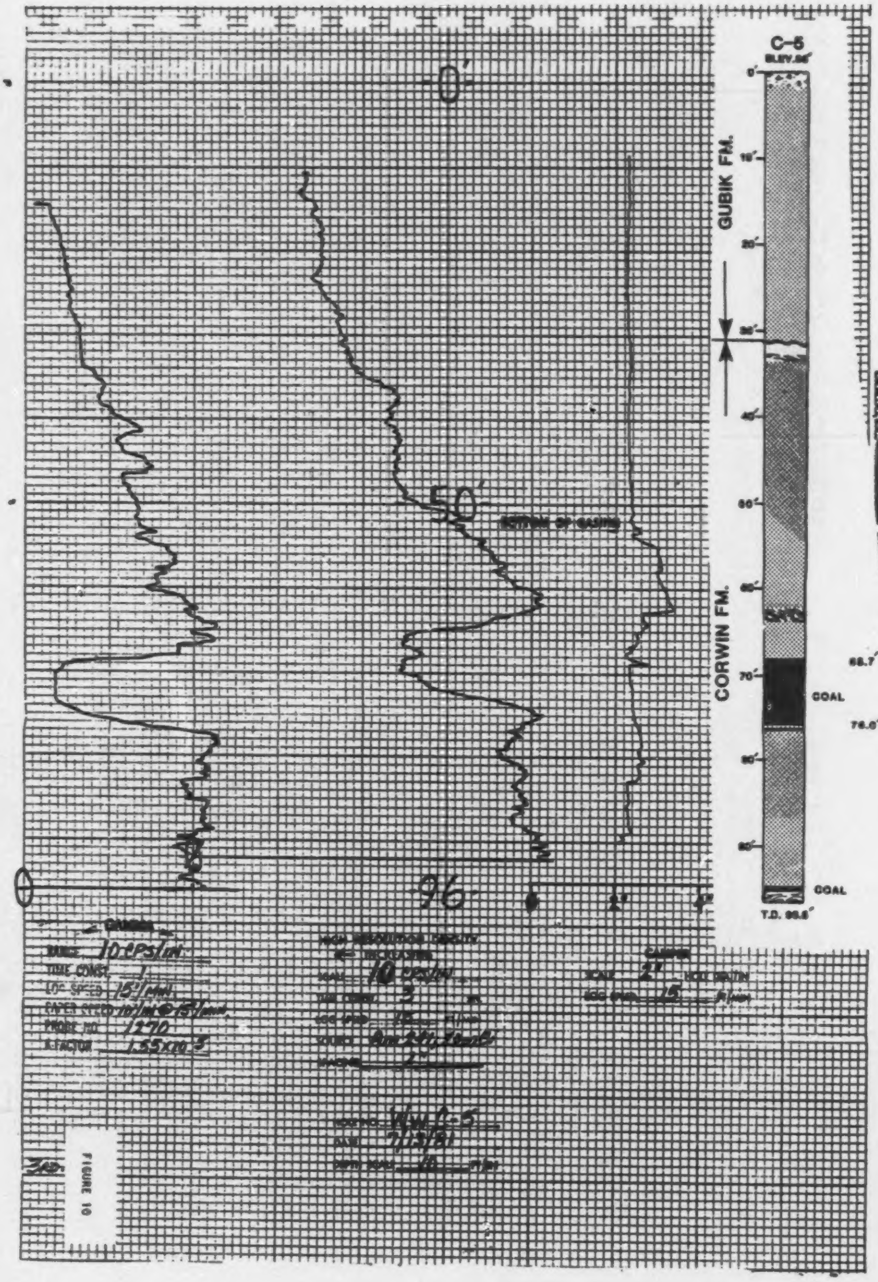
ELECTRIC LOG	
Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG
Logged Depth (ft.) 90
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

Other Services Provided:

CASING-HOLE DATA
Bit Size: 2.375 in., 0 to 96.5 ft.
Bit Size: in., to ft.
Cased From: 0 to 52 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.



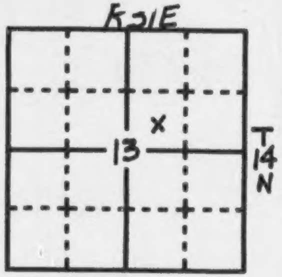
GAMMA
RANGE 10 CPS/IN.
TIME CONST. 1
LOG SPEED 15'/MIN.
PAPER SPEED 10'/IN @ 15'/min.
PROBE NO. 1270
K-FACTOR 1.55X10 3

HIGH RESOLUTION DENSITY
⟵ INCREASING
SCALE 10 CPS/IN
TIME CONST 3
LOG SPEED 15 ft/min
SOURCE Am 241
SPACING 2"

CALIPER
SCALE 2" HOLE WIDTH
LOG SPEED 15 ft/min

BORING NO. WW C-5
DATE 7/13/81
DEPTH SCALE 10 ft/in

FIGURE 10



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/14/81

HOLE: Ww C-6

Location WAINWRIGHT, ALASKA
Sec: 13 Twp: 14N Rng: 31E
State/County: ALASKA/NORTH SLOPE
Project: Ww COAL STUDY
Depth Drilled: 90.3
Measured from: GROUND LEVEL
Elevation:

CLIENT: S&D/ERTEC

Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE ROY/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	90	86		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	3	3		
Dead Time (μsec.)				
K-factor $(x10^{-5})$	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor ( ) in. steel				
Probe Number	1270	1550A		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	2½x½			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

Logged Depth (ft.) 84
Scale: 2" HOLE DIA./IN.
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS: UNPREVENTABLE SPIKES IN LOG DUE TO WATER INVASION OF TOOL.

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 90.3 ft.
Bit Size: in., to ft.
Cased From: 0 to 47 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.

Other Services Provided:

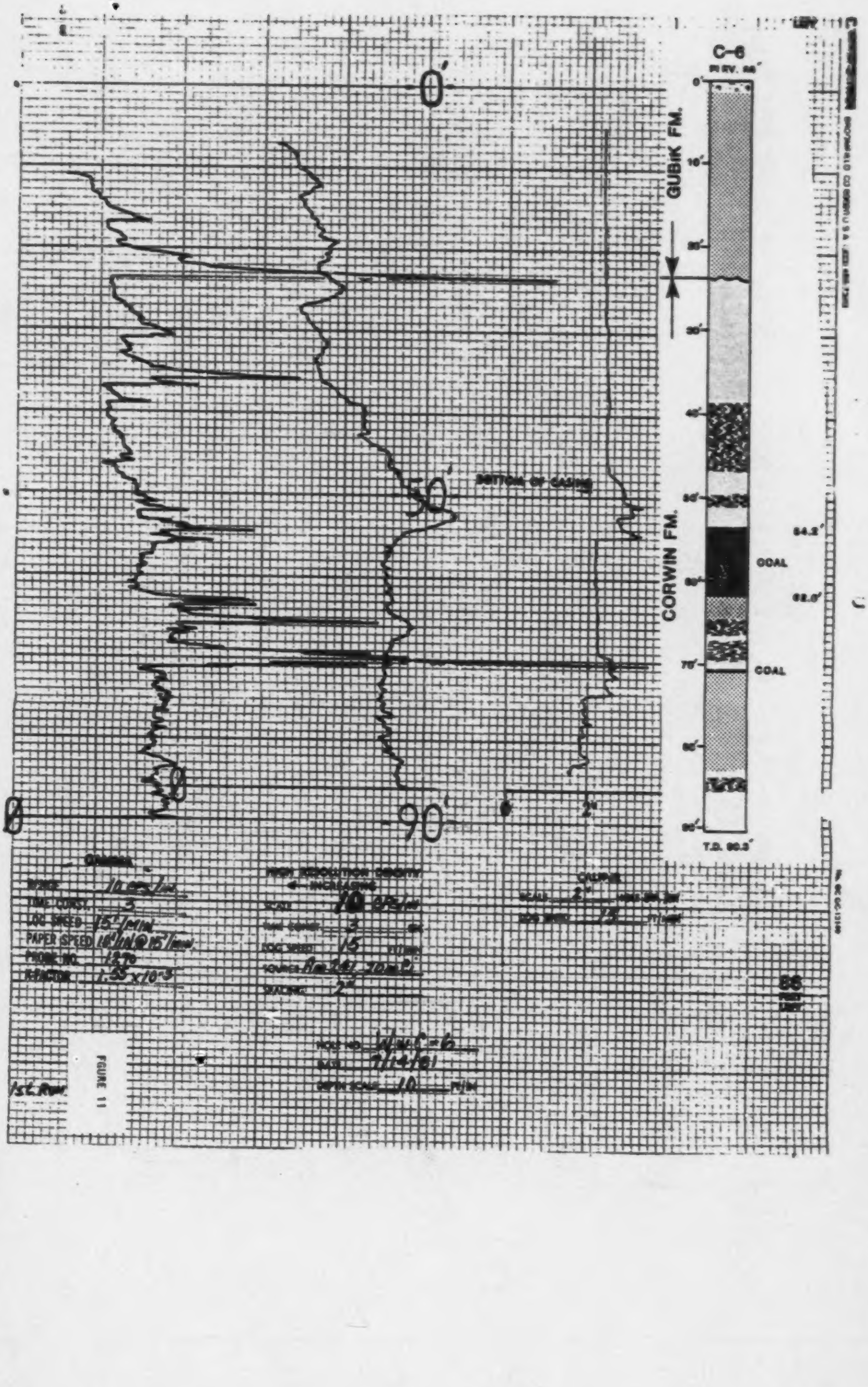
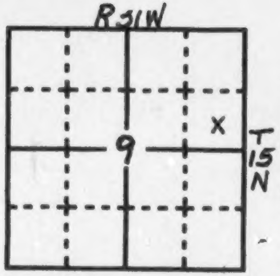

0'
50'
90'
BOTTOM OF CASING
0
2"
C-6
GR EV. 66'
0'
10'
20'
30'
40'
50'
60'
70'
80'
90'
GUBIK FM.
CORWIN FM.
COAL
COAL
54.2'
62.0'
T.D. 90.3'
GAMMA
RANGE 10 cps/in
TIME CONST. 3
LOG SPEED 15'/MIN
PAPER SPEED 10'/IN @ 15'/min
PROBE NO. 1290
K-FACTOR 1.55 x 10⁻³
HIGH RESOLUTION DENSITY
← INCREASING
SCALE 10 CPS/in
TIME CONST. 3
LOG SPEED 15 FT/MIN
SOURCE Am 241 20mCi
SPACING 2"
CALIPER
SCALE 2"
LOG SPEED 15 FT/MIN
HOLE NO. W.W. C-6
DATE 7/14/81
DEPTH SCALE 10 FT/IN
1st Run
86

FIGURE 11



DIGILOG, INC.
7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/20/81

HOLE: WwD-2

Location WAINWRIGHT, ALASKA
Sec: 9 Twp: 15N Rng: 31W
State/County: ALASKA/NORTH SLOPE
Project: Ww COAL STUDY
Depth Drilled: 96.0'
Measured from: GROUND LEVEL
Elevation: ~50'

CLIENT: S&D/ERTEC

Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE RDG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	95	91		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10⁻⁵)	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor (1/4) in. steel	1.573			
Probe Number	1270	1550A		
Probe Dia. (in.)	1 1/4	1 1/4		
Crystal Size (in.)	2 1/2 x 1/2			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

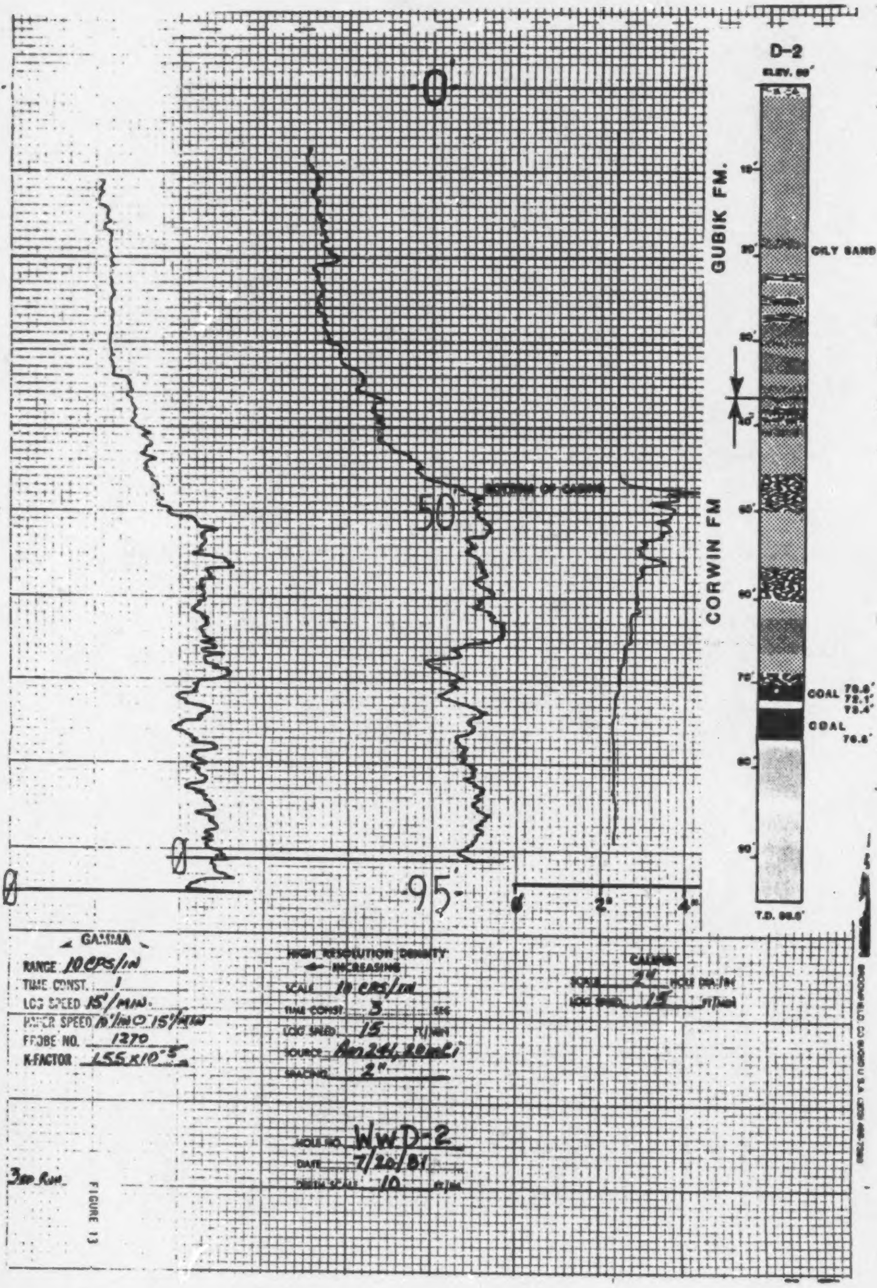
Logged Depth (ft.) 89'
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 96 ft.
Bit Size: in., to ft.
Cased From: 0 to 46 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.

Other Services Provided:



GAMMA
RANGE 10 CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN.
PAPER SPEED 10'/IN @ 15'/MIN
PROBE NO. 1270
K-FACTOR 1.55 x 10⁻⁵

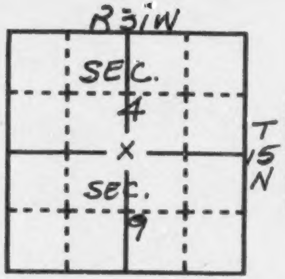
HIGH RESOLUTION DENSITY
← INCREASING
SCALE 10 CPS/IN
TIME CONST 3 SEC
LOG SPEED 15 FT/MIN
SOURCE Am 241, 20 mCi
SPACING 2"

CALIPER
SCALE 2" HOLE DIA./IN
LOG SPEED 15 FT/MIN

HOLE NO. WWD-2
DATE 7/20/81
DEPTH SCALE 10 FT/IN

3rd Run

FIGURE 13



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/22/81

HOLE: WwD-4

Location WAINWRIGHT, ALASKA
Sec: 4/9 Twp: 15N Rng: 31W
State/County: ALASKA/NORTH SLOPE
Project: Ww COAL STUDY
Depth Drilled: 103.2'
Measured from: GROUND LEVEL
Elevation: ~ 50'

CLIENT: S&D/ERTEC

Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE ROS/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

RADIATION LOG	Gamma	Density	Neutron	
Logged Depth (ft.)	103	99		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10^5)	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor (¼) in. steel	1.573			
Probe Number	1270	1550A		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	2½x½			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

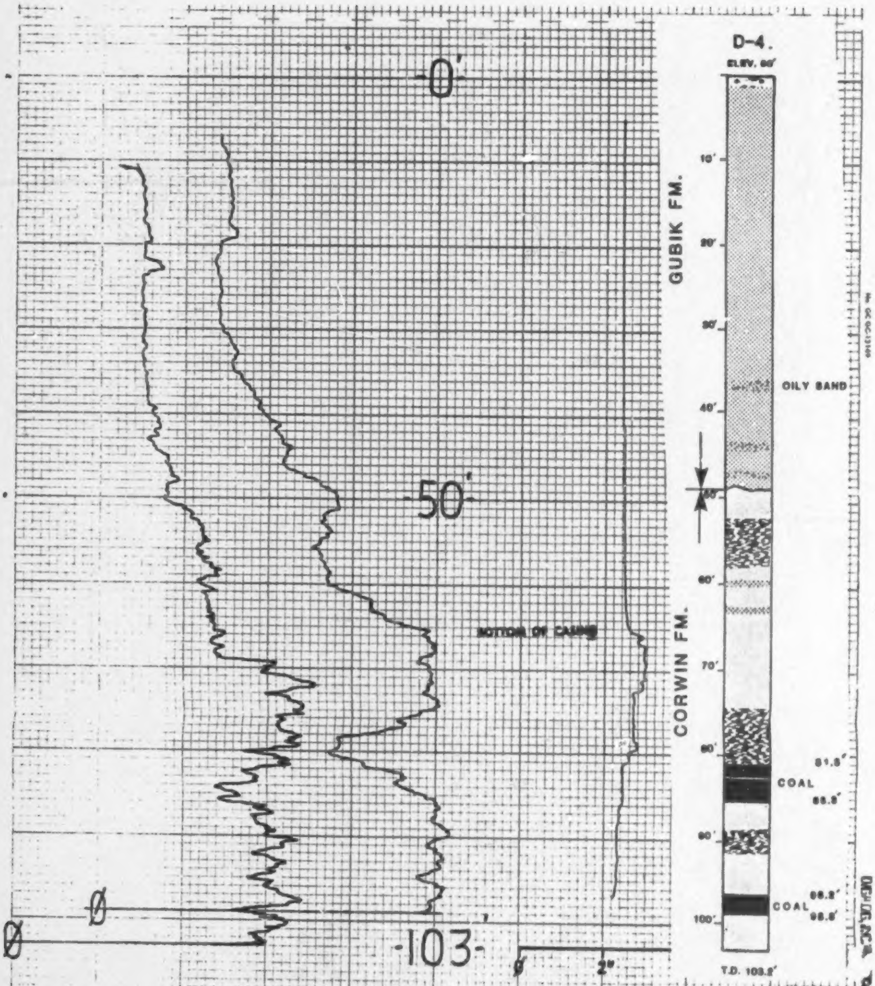
Logged Depth (ft.) 97'
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 103.2 ft.
Bit Size: in., to ft.
Cased From: 0 to 65' ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.

Other Services Provided:



GAMMA
RANGE 10 CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN
PAPER SPEED 10'/IN @ 15'/MIN
PROBE NO. 1270
K-FACTOR 1.55 x 10^-5

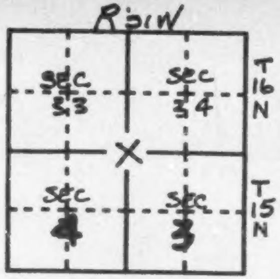
HIGH RESOLUTION DENSITY
← INCREASING
SCALE 10 CPS/IN
TIME CONST. 3 SEC
LOG SPEED 15 FT/MIN
SOURCE Am 241, 20 mCi
SPACING 2"

CALIPER
SCALE 2" HOLE DIA./IN
LOG SPEED 15 FT/MIN

HOLE NO. W.W.D-4
DATE 7/22/81
DEPTH SCALE 10 FT/IN

3RD RUN

FIGURE 14



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/23/81

HOLE: WWD-A5

Location WAINWRIGHT, ALASKA
Sec: Twp: Rng:
State/County: ALASKA/NORTH SLOPE
Project: WW COAL STUDY
Depth Drilled: 98.9
Measured from: GROUND LEVEL
Elevation: 45'

CLIENT: S&D/ERTEC

Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE ROG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	97	93	.	
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10⁵)	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor (1/4) in. steel	1.573			
Probe Number	1270	1550A		
Probe Dia. (in.)	1 1/4	1 1/4		
Crystal Size (in.)	2 1/2 x 1/2			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

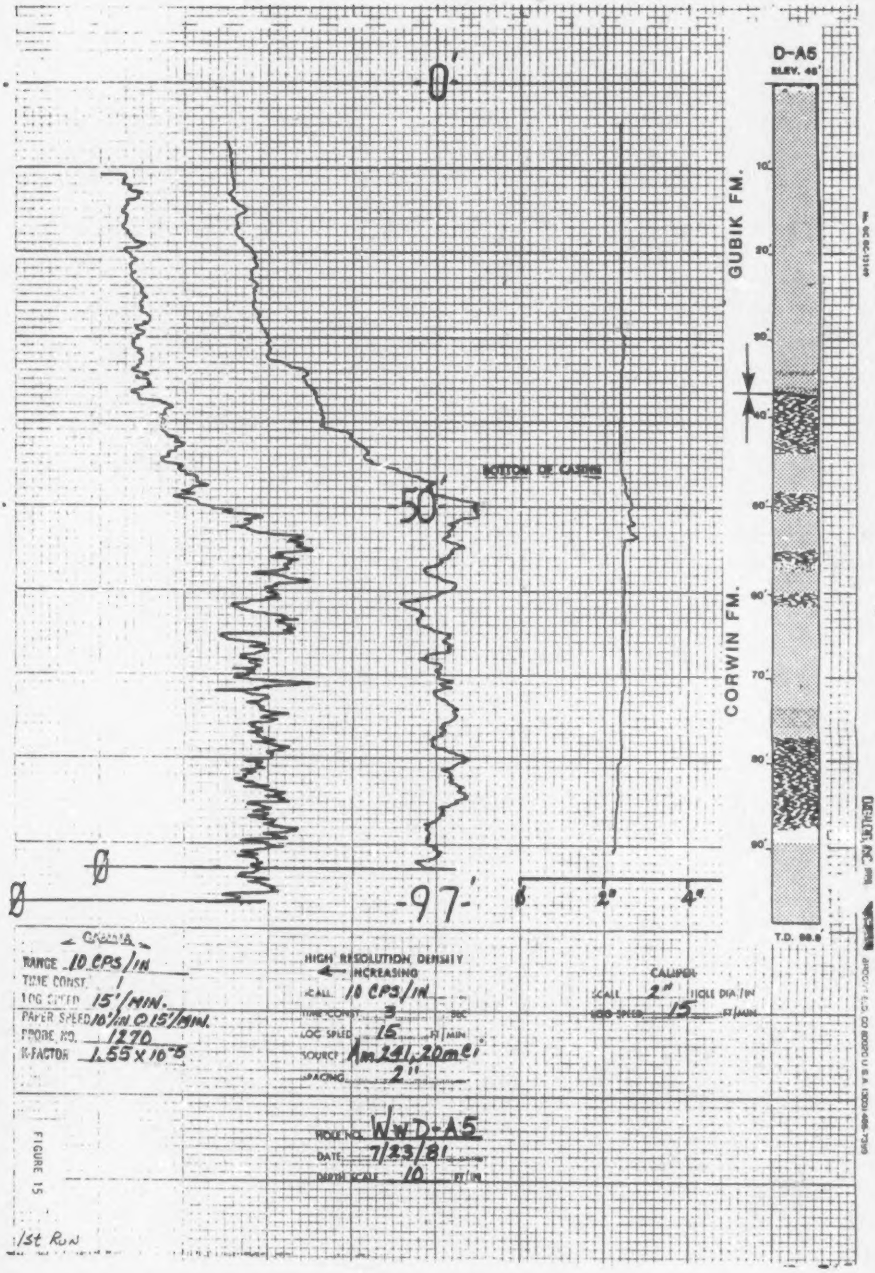
Logged Depth (ft.) 91
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 98.9 ft.
Bit Size: in., to ft.
Cased From: 0 to 47 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.

Other Services Provided:



GAMMA

RANGE 10 CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN.
PAPER SPEED 10'/IN @ 15'/MIN.
PROBE NO. 1270
K-FACTOR 1.55 x 10^{-5}

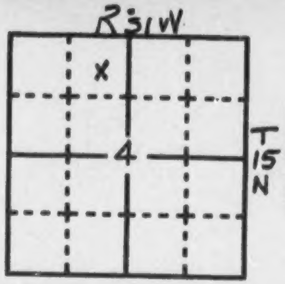
HIGH RESOLUTION DENSITY
← INCREASING
SCALE 10 CPS/IN
TIME CONST. 3 SEC
LOG SPEED 15 FT/MIN
SOURCE Am 241, 20mCi
SPACING 2"

CALIPER
SCALE 2" HOLE DIA./IN
LOG SPEED 15 FT/MIN

HOLE NO. WWD-A5
DATE 7/23/81
DEPTH SCALE 10 FT/IN

FIGURE 15

1st Run



DIGILOG, INC.
7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/24/81

HOLE: WwD-Ab
Location WAINWRIGHT, ALASKA
Sec: 4 Twp: 15N Rng: 31W
State/County: ALASKA/NORTH SLOPE
Project: WW COAL STUDY
Depth Drilled: 97.3'
Measured from: GROUND LEVEL
Elevation: ~ 35'
CLIENT: S&D/ERTEC
Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE RIX/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	97	93		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10⁻⁵)	1.55			
Water Factor ( ) in. hole	1.14			
Casing Factor (1/4 in. steel	1.573			
Probe Number	1270	1550A		
Probe Dia. (in.)	1 1/4	1 1/4		
Crystal Size (in.)	2 1/2 x 1/2			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPERLOG

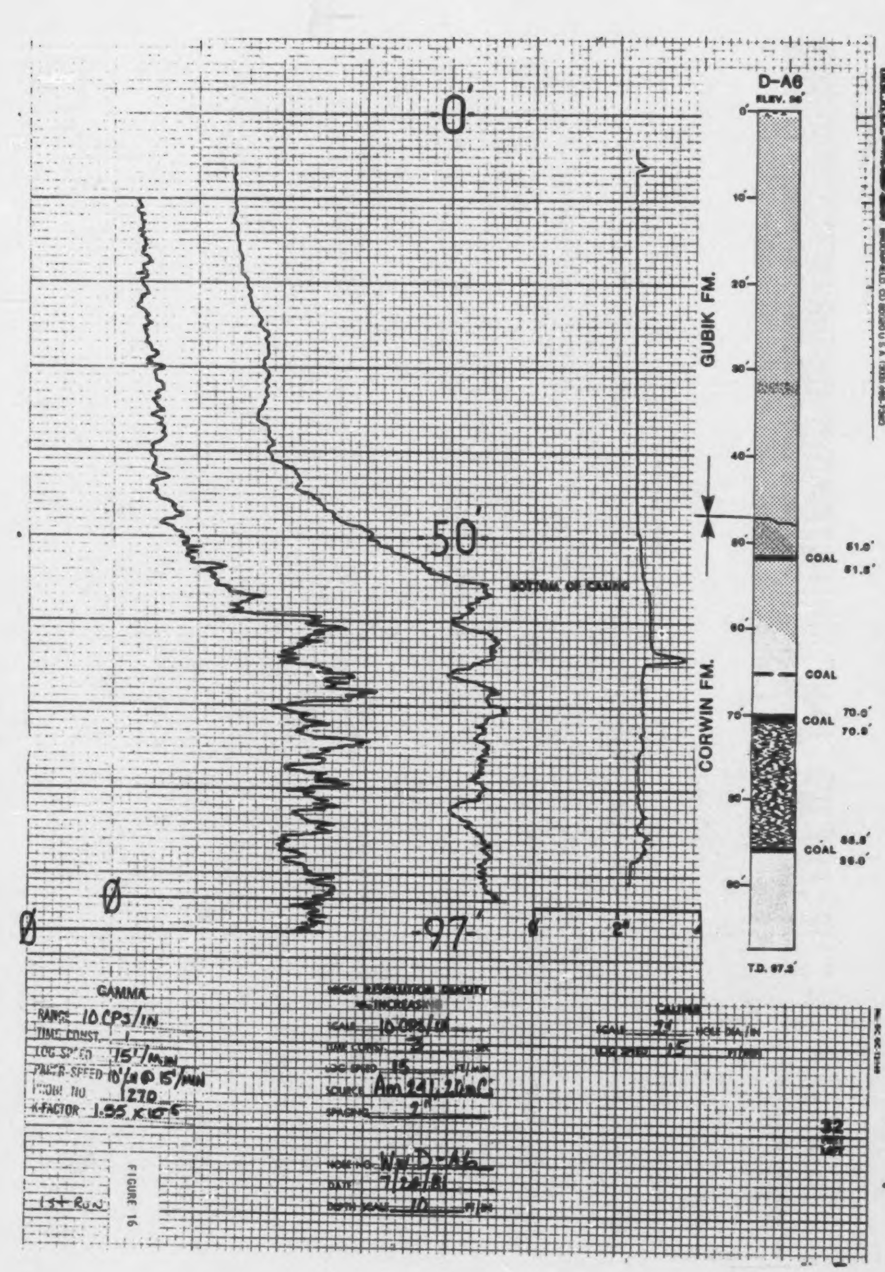
Logged Depth (ft.) 91
Scale: 2" HOLE DIA/IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 97.3 ft.
Bit Size: in., to ft.
Cased From: 0 to 55 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.

Other Services Provided:



GAMMA
RANGE 10 CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN
PAPER-SPEED 10'/IN @ 15'/MIN
PROBE NO 1270
K-FACTOR 1.55 x 10⁻⁶

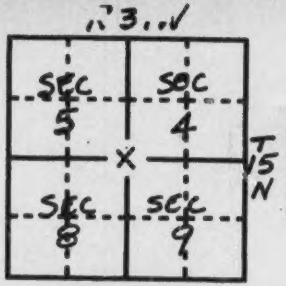
HIGH RESOLUTION DENSITY
% INCREASING
SCALE 10 CPS/IN
TIME CONST. 3 SEC
LOG SPEED 15 FT/MIN
SOURCE Am 241, 20mCi
SPACING 7"

CALIPER
SCALE 2" HOLE DIA./IN
LOG SPEED 15 FT/MIN

HOLE NO. W D-A6
DATE 7/28/81
DEPTH SCALE 10 FT/IN

1st RUN

FIGURE 16



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/25/81

HOLE: WWD-7

Location: WAINWRIGHT, ALASKA
Sec: Twp: 15N Rng: 31W
State/County: ALASKA/NORTH SLOPE
Project: NW COAL STUDY
Depth Drilled: 100'
Measured from: GROUND LEVEL
Elevation: ~ 49'

CLIENT: S&D/ERTEC

Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE ROG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

	Gamma	Density	Neutron	
Logged Depth (ft.)	100	96		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10^{-5})	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor (¼ in. steel	1.573			
Probe Number	1270	1550A		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	2½ × ½			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

Logged Depth (ft.) 94'
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS: DURING AN ATTEMPT FOR A 2ND LOG OF HOLE, TEST PROBE GOT STUCK ON THE WAY UP @ 75' APPROX. — DUE TO PROBABLE HOLE DETERIORATION. ATTEMPTS TO DISLODGE TOOL WERE UNSUCCESSFUL. IT WAS DECIDED TO CUT CABLE (100' FT.) AND OVERSHOOT CABLE AND PROBE WITH DRILL PIPE AND RETRIEVE. IT WAS SUCCESSFUL AND PROBE WAS UNHARMED (TO REHEAD FOLLOWING DAY)

Other Services Provided:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 100 ft.
Bit Size: in., to ft.
Cased From: 0 to 58 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.

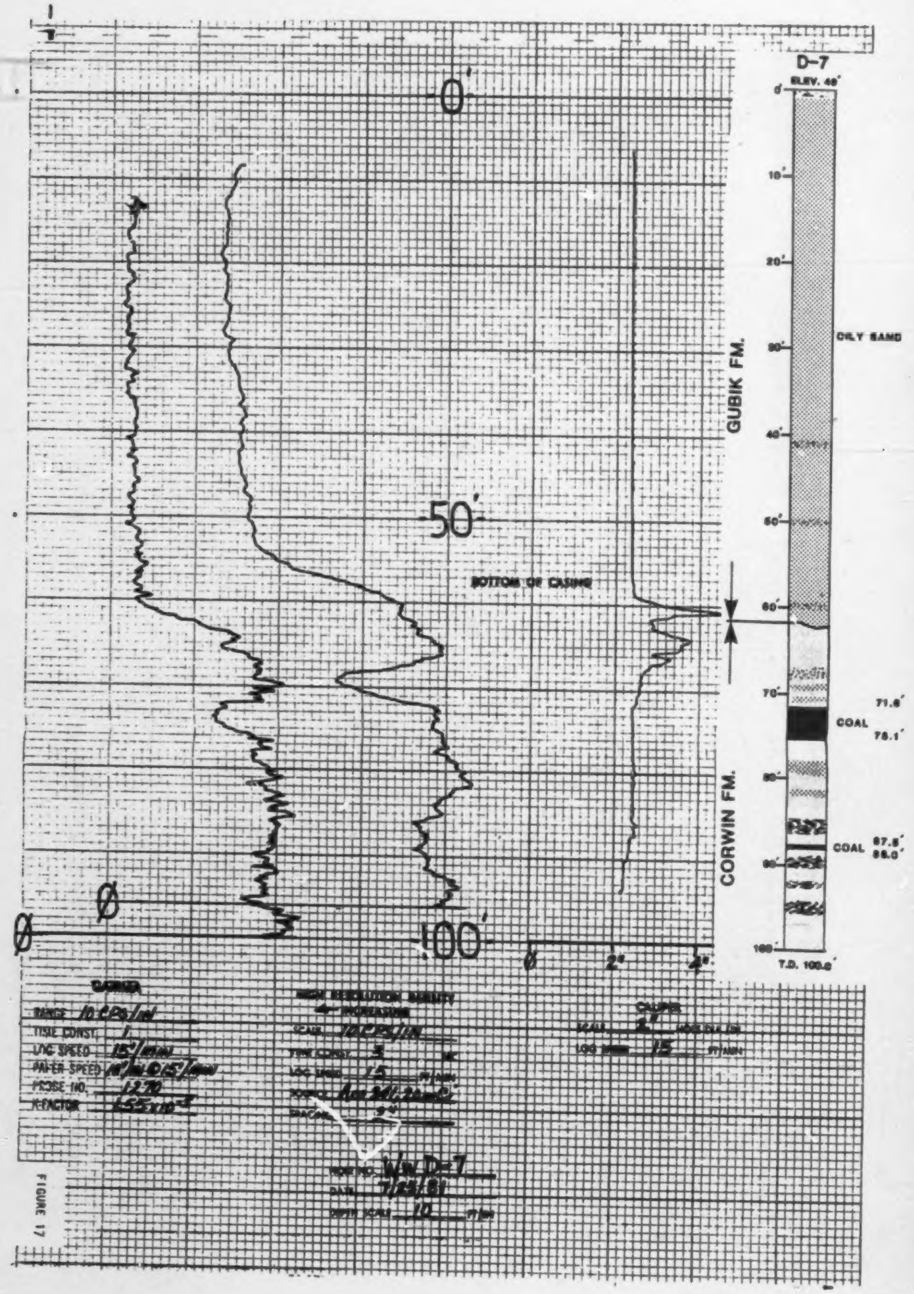
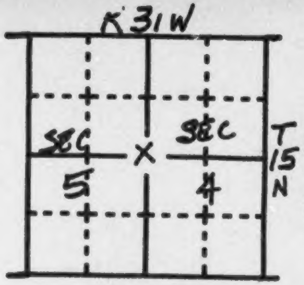

0'
50'
100'
BOTTOM OF CASING
GUBIK FM.
CORWIN FM.
0
2"
4"
D-7
ELEV. 40'
0'
10'
20'
30'
40'
50'
60'
70'
80'
90'
100'
OILY SAND
COAL
71.6'
76.1'
COAL
87.5'
88.0'
T.D. 100.0'
GAMMA
RANGE 10 CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN
PAPER SPEED 10"/IN @ 15'/MIN
PROBE NO. 1270
K-FACTOR 1.55x10⁻³
HIGH RESOLUTION DENSITY
SCALE 1ACPS/IN
TIME CONST. 3 SEC
LOG SPEED 15 FT/MIN
SOURCE
SPACING 2"
HOLE NO. W/W D-7
DATE 7/25/81
DEPTH SCALE 10 FT/IN
CALIPER
SCALE 2"
LOG SPEED 15 FT/MIN

FIGURE 17



DIGILOG, INC.

7001 West 117th Avenue Suite One
Broomfield, Colorado 80020
(303) 466-7389

Date 7/26/81

HOLE: WwD-A8

Location WAINWRIGHT, ALASKA
Sec: 4 & 5 Twp: 15N Rng: 31W
State/County: ALASKA/NORTH SLOPE
Project: Ww COAL STUDY
Depth Drilled: 97.5'
Measured from: GROUND LEVEL
Elevation: ~ 49'

CLIENT: SID/ERTEC

Drilling Co.: SALISBURY & DIETZ
Geologist: STEVE ROG/KIM MARCUS
Unit Operator: C. DAVIS
Unit Number: T-3
Job Number: 64.01

RADIATION LOG

RADIATION LOG	Gamma	Density	Neutron	
Logged Depth (ft.)	97	93		
Rerun Interval (ft.)				
Range (cps./in.)	10	10		
Counts Increasing to:	→	→		
Depth Scale (ft./in.)	10	10		
Logging Speed (ft./min.)	15	15		
Time Constant (sec.)	1	3		
Dead Time (μsec.)				
K-factor (x10^{-5})	1.55			
Water Factor ( ) in. hole	1.04			
Casing Factor (1/4 in. steel	1.573			
Probe Number	1270	1550A		
Probe Dia. (in.)	1¼	1¼		
Crystal Size (in.)	2½"x½			
Print Out (ft.)				
Reference Source (cps.)				

ELECTRIC LOG

Logged Depth (ft.)	
Resistance Scale (Ω/in.)	
S.P. Scale (mv/in.)	
16" Normal Resistivity (Ωm/in.)	
64" Normal Resistivity (Ωm/in.)	
Logging Speed (ft./min.)	
Viscosity-Density	
Rm. @ T°F	
Rmf. @ T°F	
Rmc. @ T°F	

CALIPER LOG

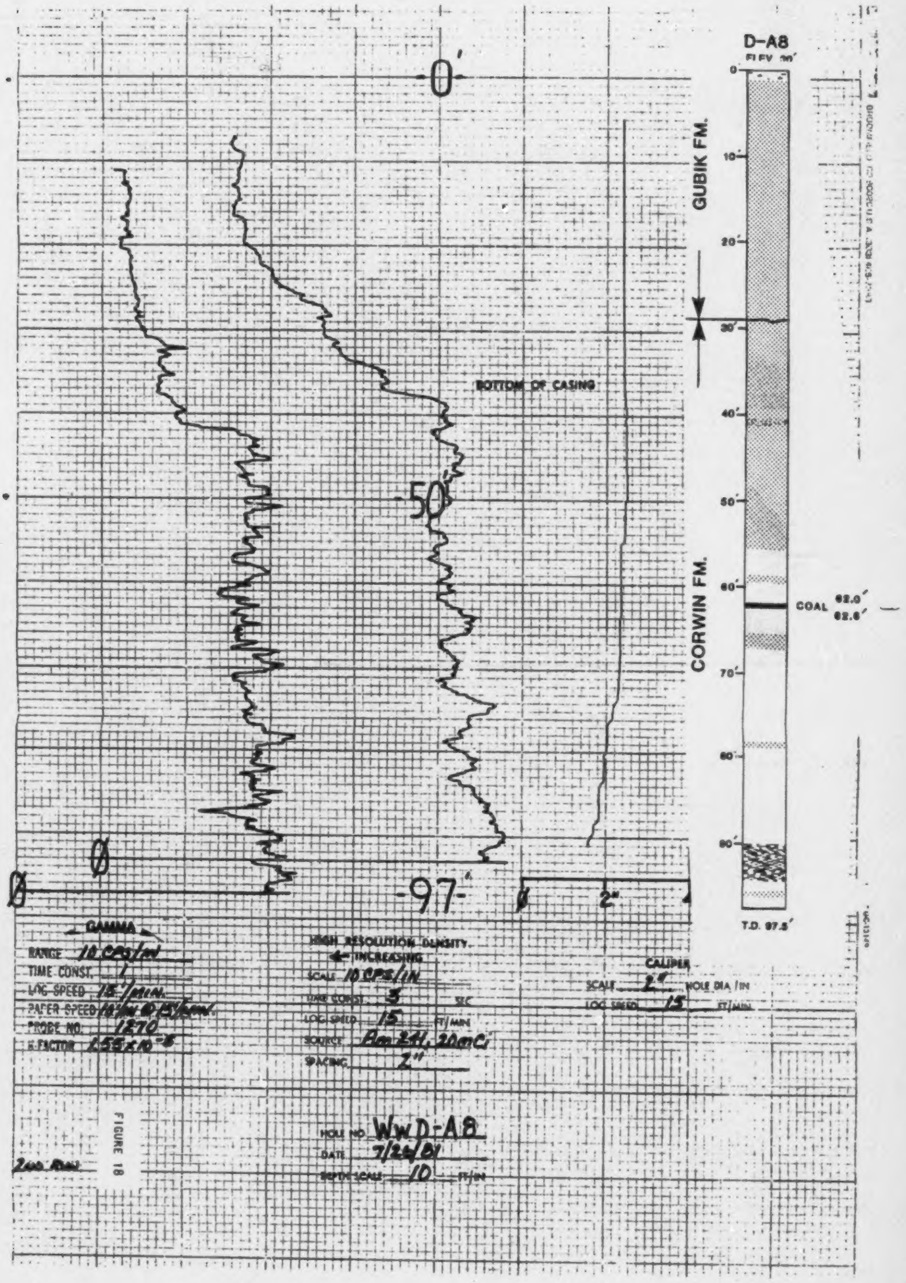
Logged Depth (ft.) 91
Scale: 2" HOLE DIA./IN
Depth Scale (ft./in.) 10
Logging Speed (ft./min.) 15

REMARKS:

Other Services Provided:

CASING-HOLE DATA

Bit Size: 2.375 in., 0 to 97.5 ft.
Bit Size: in., to ft.
Cased From: 0 to 37 ft.
Dia. (inside): 2.385 in., wall size 1/4 in.
Cased From: to ft.
Dia. (inside): in., wall size in.



GAMMA

RANGE 10 CPS/IN
TIME CONST. 1
LOG SPEED 15'/MIN.
PAPER SPEED 10'/IN @ 15'/MIN.
PROBE NO. 1270
K-FACTOR 1.55 x 10⁻⁵

HIGH RESOLUTION DENSITY
← INCREASING
SCALE 10 CPS/IN
TIME CONST. 5 SEC
LOG SPEED 15 FT/MIN
SOURCE Am 241, 20 mCi
SPACING 2"

CALIPER
SCALE 2" HOLE DIA /IN
LOG SPEED 15 FT/MIN

HOLE NO. WWD-A8
DATE 7/26/81
DEPTH SCALE 10 FT/IN

2ND RUN

FIGURE 18

CENTRAL DISTRICT HEATING AND POWER GENERATION PROJECT

Prepared for
NORTH SLOPE BOROUGH

VOLUME THREE

PRELIMINARY MINE DESIGN

Prepared by
Arctic Slope Technical Services, Inc.
420 L Street, Suite 406
Anchorage, Alaska 99501

February 1982

4.01.0 SUMMARY AND RECOMMENDATIONS - MINING

4.01.1 INTRODUCTION

Current literature on Arctic mining and on North Slope coal reserves is very limited. Available information was reviewed in detail and used to augment the drilling program conducted during the summer of 1981 as part of this study. Section 4.01.2 details the ASTS recommendations resulting from this study.

4.01.2 RECOMMENDATIONS - MINING

1. Adequate coal reserves are present near the village of Wainwright to support a coal-fired generating station that could supply electric power and heat to the village.

2. It is suggested that an underground mine best suits the project based on cost, reserve location, and climatic conditions.

3. It is projected that operating and amortized capital costs for a small room and pillar mine to supply 10,000 tons of coal per year will approximate $73 per ton based on the assumptions detailed in Section 4.03.0 of this report. The grant for 50 percent of the capital and the low interest rate on the balance are vital in achieving this cost.

4. It is recommended that the mine be operated only during the winter months to facilitate maintaining frozen conditions.

5. Capital costs for a small operation are very sensitive to small changes in life and tonnage. For instance, if the power plant only requires 5,000 tons per year instead of the design 10,000, total costs will exceed $91 per ton - all else being equal.

6. A detailed training program will be required to train local labor to operate and maintain specialized underground mining equipment. It may also be necessary to bring in an outside expert periodically.

7. A source of gravel for constructing an all-weather road to the mine has not been identified. This requirement should be met early in the project schedule.

8. The selected mine site (drilling Area A-B) is based on only three widely spaced drill holes. Additional drilling should be completed early in the project schedule to confirm specific mine location.

9. A detailed underground mine plan should be submitted to the Mine Safety and Health Administration early in the project schedule with specific attention to two areas which may require variances: 1) rock dusting and 2) dust supression without water sprays.

4.02.0 SURFACE MINE

4.02.1 INTRODUCTION

The drilling conducted during the summer of 1981 located two areas near Wainwright which contain attractive coal reserves; Area C, approximately eight and one half miles southwest of the village; and Area A-B, approximately one mile to the northeast as indicated on location map, figure 3-2, volume 2.

Neither of these areas was shallow enough to be attractive as a surface mine reserve for a small tonnage operation. Area C averaged 70 feet deep and Area A-B averaged 130 feet deep. The coal seam at Area C is typically eight feet thick, which is better than A-B, with only six and one half feet of good coal; however Area C's longer haul makes Area A-B a rather obvious choice for an underground operation.

Coal outcrops along both banks of the Kuk River. Areas were observed where strippable coal could be obtained (under less than 50 feet of cover). However, all of these locations would involve relatively long hauls and the problems associated with permitting, operating, and reclaiming a surface mine near a major river make surface mining appear to be an unrealistic choice.

4.02.2 PRELIMINARY COST CONSIDERATIONS

Maintaining coal haulage during the summer season would require an all-weather road, which would be a major expense. It also appears that pit operations during the summer are complicated by water, mud, and unstable pit walls. It is recommended that a surface mine be scheduled for operation only during frozen conditions and that all coal haulage be conducted over frozen roads.

ASTS previously submitted a gravel mining study to the North Slope Borough, dated September 28, 1981. Preliminary cost estimates are included in that report for an upland gravel mining operation. Overburden stripping for coal would be similar to mining gravel and pre-stripping for an upland gravel pit. Therefore, the upland gravel mining costs were reviewed to obtain preliminary open pit costs.

Assumptions:

1. A suitable site can be located with 30 to 50 feet of overburden.
2. Mining would be conducted only during the eight months of frozen conditions.
3. An average coal thickness of seven and one half feet of good coal is available.
4. Mining recovery will equal 90 percent.
5. Coal density equals 1,760 tons per acre-foot.

Calculations:

7.5 ft. x 90% x 1,760 TPAF = 11,800 recoverable tons per acre

$$\frac{\text{10,000 tons required}}{\text{11,880 tons per acre}} = \text{0.85 acres per year}$$

$$\frac{\text{0.85 acres x 40 ft. overburden x 43,560 sq. ft./acre}}{\text{27 cu. ft./cu. yd.}} = \text{54,853 cu. yds.}$$

54,853 cu. yds. x $3.24/cu. yd. (from gravel report) = $180,466 annual stripping cost after pit established

$$\frac{\text{\$180,466}}{\text{10,000 tons}} = \text{\$18.05 per ton for stripping only}$$

Preliminary Operating Cost Summary

Overburden stripping	$18.05	per ton
Coal blasting and loading	3.29	per ton
Coal hauling (eight miles)	10.86	per ton
	$32.20	per ton

To this number must be added capital costs of $47 (see Table 4.2.1), permitting costs, any federal royalties and taxes, and reclamation costs. This high preliminary capital and operating cost and the fact that a suitable site has not been identified indicates that an underground mine may be more attractive and should at least be considered. A surface mine will be extremely sensitive to changes in tonnage; for instance, if only 5,000 tpy were required, costs would go from $79 per ton to over $126 per ton.

4.02.3 CONCLUSION

Based on the preceding analysis, it was decided to design an underground coal mine to develop the coal reserves at Area A-B. If the underground operation does not appear feasible, a detailed reevaluation of surface mining options can be made at that time.

TABLE 4.2.1

SURFACE MINE
Capital Cost

Item	Cost $ x 1,000 (Lower 48 x 1.5)	Life* (Yrs.)	Depreciation $/ton (Prorated @ 10,000 Tpy)
1 Dozer D-9H	598	10	5.98
1 Loader 988-B	486	10	4.86
2 Dump Trucks	420 ea.	10	8.40
1 Drill	240	10	2.40
1 Explosives Truck	23	10	0.23
1 Personnel Vehicle	18	5	0.36
Subtotal	2,205		$22.23

Road Construction 8 miles @ $200,000 per mile = $1,600,000 = $ 8.00 (20 yrs.)

Grader @ $ 375,000 and 10 year life = $ 3.75
Subtotal: $1,975,000 $11.75 per ton

Mine Shop and Warehouse 40 x 80 = 3,200 sq. ft.
3,200 sq. ft. x $75/sq. ft. = $240,000
prorated over 20 years = $1.20 per ton

Total Capital = $4,420,000
50% grant and 50% at 8% interest

Interest on $2,210,000 for 20 years = $11.46 per ton (calculated as constant payment mortgage loan)

Total Capital per ton approximates $35.18 equipment sinking fund plus $11.46 loan interest for a total of $46.64 per ton.

* The equipment will have low hourly usage per year but the severe climate and unskilled personnel will limit the life of the equipment.

If equipment is used on other projects when the mine is idle, appropriate hourly charges must be made, or the equipment costs for coal will be higher than estimated.

4.03.0 UNDERGROUND MINE

4.03.1 INTRODUCTION

This report has been developed to provide a reasonable mine layout and associated cost estimate for delivering coal to a small generating station contemplated at Wainwright, Alaska. The annual production requirement of 10,000 tons per year is quite small so that a deposit capable of supporting the generating unit over a 20-year life would not be extensive.

Several coal deposits are known near Wainwright and have been reported on by the U. S. Bureau of Mines and others over the past few decades. Intermittent mining by the natives has been conducted several miles south of Wainwright along the banks of the Kuk River, and the Alaska Native Service at one time operated a mine on the Meade River some 70 airline miles from Wainwright. These sites, while workable, present a problem in transportation.

A modest drilling program conducted during the 1981 field season disclosed the presence of a small coal deposit on the immediate outskirts of the village of Wainwright (Area A-B on location map, figure 3-2, Volume 2.) The coal is quite shallow, appears to maintain a reasonable thickness, and is sufficiently continuous to provide at least a 20-year fuel supply. Because of these factors and the obvious lack of men, material, and coal transportation problems, this site was selected for analysis.

4.03.2 SUMMARY

The Wainwright mine is sized to produce 10,000 tons per year by the underground room and pillar method. It is planned that it will be active only half time during the eight winter months so considerable excess capacity exists for possible future expansion.

A simplified approach was used in laying out the mine and in selecting equipment. This, together with the excess capacity mentioned above, should ensure reliable coal production.

The 20-year mine life reserve block encompasses an area of just 50 acres. Pillar sizes are believed more than ample to support the overlying cover (particularly if the mine remains cold) and they will be left intact to avoid complicating the mining process. Resource recovery under these conditions approximates 35 percent.

Actual construction time for the mine can be in the final months of the year preceding coal deliveries as shown on Figure 4.3.4. In this manner full use can be made not only of the short shipping season but also of the subsequent frozen ground conditions when the incline entry and shaft need to be excavated. It is presumed that the contractor will use local labor to the fullest extent possible so that they will be adequately trained to eventually run the mine. Maximum contractor employment will be 22, whereas the mine staff will total 14 people, comprised of 11 hourly personnel and 3 salaried staff members.

Total initial capital requirements to make the mine operational will approach $2,977,000. Given some unique financing arrangements, those capital and operating costs attributable only to mining are calculated to be $72.72 per ton.

4.03.3 RESERVE ANALYSIS

Basic data on the coal seam indicate that it lies approximately 120 feet below the ground surface, has a very gentle dip to the south-southeast, and carries at least a 6.5-foot thickness over a considerable area. It should be noted that this information is derived on the basis of three or four drill holes, the closest of which are over 2,600 feet apart, and that prior to any detailed study or decision some additional subsurface information should be collected.

Underground mining is the preferred choice in this situation. Some basic assumptions which have been made in order to define a mining block and determine a reserve requirement include the following:

1. Standard underground room and pillar mining would be employed.

2. No pillar recovery has been planned initially, but pillar recovery can be added after mining skills are developed at Wainwright.
3. Entries would be 18 feet wide on 80-foot centers; this will leave pillars 62 feet square which should be ample for support given the shallow cover depth.
4. A three-entry system will be considered for both the mains and panels in order to satisfy current federal requirements.
5. Mining will be done to the full seam height of 6.5 feet.
6. A barrier pillar will be left between panels so that sealing and complete abandonment can be effected upon completion of mining in any given panel. This obviates the need for sweeping old workings with a split of air during the remaining mine life.

Table 4.3.1 shows the calculation of reserve recovery under these assumptions to be 46 percent in the main entries and 34 percent in the panels. Based on these figures, further calculations suggest that eight panels of approximately 1,000 feet in length will be required (in addition to the production from main entry development) to supply the proposed generating unit. The overall block of ground disturbed at the end of 20 years' operation will measure roughly 1,138 feet x 1,938 feet. Slightly over 200,000 tons of coal can be produced from this block at an overall recovery of nearly 35 percent.

4.03.4 MINE LAYOUT AND PLANNING

Access to the coal seam logically would be via an inclined entry. The shallow cover depth will allow a relatively gentle grade without excessive length, and an inclined entry provides efficiency in men, material, and coal transport. As an emergency escapeway, however, a shaft will also be provided; this can double as an exhaust ventilation airway.

Figure 4.3.1, at the end of this section, is a conceptual mine layout illustrating the relationship of the main and panel entries, the main roadway, and the ventilation airways; in keeping with the Mine Safety and Health Administration (MSHA) requirements, the three-entry system will allow one fresh air intake, one neutral airway, and a separate exhaust path. The panels are positioned solely on one side of the main entries for simplicity and to meet MSHA regulations regarding sealed panels - i.e., the seals should be swept by return air or else they require daily inspections. The proposed layout can meet these requirements and still avoid the need for expensive ventilation overcasts.

The coal seam and surrounding sediments lie within the permafrost zone, and the frozen condition will be maintained during mining. The ambient temperature underground is estimated to be 20 to 22 degrees Fahrenheit and a long intake entryway is preferred so the incoming ventilation air is afforded ample opportunity to reach a stable temperature. Thus the incline will serve as the intake entry. Thawing problems can be minimized if operations cease during the summer months; because of the minimal tonnage required, production can be maintained by winter operations only.

Figure 4.3.2 affords a more general view of the mining block as it would appear after 20 years' production. The inclined entry will be about 788 feet long, given a 120-foot coal seam depth and a slope of 16 percent (9 degrees). This inclination was selected since it would allow construction and eventual coal transport through the entry by diesel driven equipment. The escapeway position near the incline entry provides emergency egress as early in the mine life as possible. Even at the farthest reaches of the mine, personnel will only have to travel 3,000 feet to the shaft, much less than in some conterminous United States mines. The opportunity does exist that later a second escapeway could be constructed more proximate to the current workings if desired.

Maps 4.1 through 4.4 illustrate the proposed location of the mine in relation to geological and topographic characteristics at the site. The orientation is such that main entries will be driven parallel to the seam strike and all panel development will be updip. The positioning of the incline entry considers a surface opening location part way up a topographic rise to avoid as much as possible water seepage into the entrance during summer and prevailing westerly winds in the winter. Also in this position, the entry should enter the coal seam where it is 6.5 feet thick. The mine portal will be appoximately 4,500 feet from Wainwright.

Figure 4.3.3 is a cross section of the incline entry and shaft together with a generalized geologic column for reference. Anticipated support requirements for each surface opening are shown depending on the type of strata penetrated and the need to maintain the integrity of the opening over a 20-year period.

In this analysis it is presumed that the first 50 feet of slope entry will be a cut and cover construction approach using a metal shell covered with an insulating agent such as polyurethane foam. A 50-foot level section will be similarly constructed to provide a means of hanging doors and sealing the mine in the summer, as well as to allow the installation of an intake air heater.

The next 170 feet of incline passes through near surface, sandy material and is a candidate for bolt and mesh support sealed with insulating foam. This should protect against ground weakening caused by summer thawing or overheated intake air. Other roof bolt/mesh segments of entry support are positioned in areas where shale or coal stringers occur in the roof. In fact this may be somewhat overdesigned if the ground remains frozen and exhibits good structural integrity as a result. Once in the coal seam, roof bolting practices as dictated by MSHA will be followed.

A complete metal lining is planned for the shaft, partly for ground support but mostly as a base for attaching the necessary escape ladders and platforms. The upper 25 feet of shaft would be insulated for protection against thawing. Table 4.3.2 summarizes the ground support materials required.

An overriding concern in this feasibility analysis has been to keep the layout, equipment list, and operational approach as simple as possible, recognizing both the remoteness of location and the current lack of underground mining experience at Wainwright. It is anticipated that a contractor would be retained to drive the incline entry and sink the exhaust shaft. During this period, the contractor would use local labor as much as possible and train them in mining techniques, equipment handling, and maintenance. If the same equipment could be used in driving the incline entry and then used in mining coal, any applicable training would have full transference.

Air and battery powered equipment are not believed to be applicable at Wainwright. Air powered units in a cold environment require continuously removing entrained moisture from the airstream. Battery equipment loses efficiency with decreasing temperatures and invariably fails to get recharged on schedule. Thus only electric and diesel driven equipment are considered in this study.

Discussions with equipment vendors and manufacturers' representatives resulted in selection of the following primary equipment items as adequate for Wainwright. More detailed analysis should be performed at some later date in an effort to optimize the equipment list.

Excavator:	Dosco Dintheader - capable of driving the incline and mining coal; a simple, low maintenance electrically driven unit that can excavate and load the material directly into a hauler. Avoids the need for using explosives and mitigates associated training and safety problems that would be present in a "conventional" coal cutting, augering and blasting system.
Bolter:	Long-Airdox LRB-15A - capable of bolting either rock or coal, and included in this analysis as a worst case situation. Dosco manufactures a hydraulically operated drill which can be mounted and run off the

Dintheader. This attachable unit has the potential to save capital costs and labor charges, and should be considered in detail in any future study.

Hauler: Jeffrey Ramcar - this diesel driven unit has a low profile and it can fit under the discharge boom of the Dintheader in a 6.5-foot opening. It provides good visibility for the operator, and with four-wheel drive can haul 14 tons of coal up the incline to the discharge point.

Exhaust fan: A standard off-the-shelf unit rated at a nominal 40,000 CFM capacity but has a range of 20,000 to 60,000 CFM depending on blade setting.

Air Heater: Two units were selected so that large variances between outside temperature and air volumes can be taken into account. Each unit will require 305 kW and should be able to heat 20,000 CFM from -40 degress Fahrenheit to 20 degrees Fahrenheit.

It is expected that the Dintheader and the bolter can be operated without the use of water sprays. A variance may be required from MSHA for this. However, the Dintheader can load coal at the rate of roughly 4 tons per minute so that only 3.5 minutes of operation will be needed to fill the hauler. Transport cycle time to the generating station at Wainwright is estimated to be nearly 29 minutes, allowing ample time for clearing any dust generated during the cutting cycle (see Table 4.3.3 for general assumptions and calculations).

Permafrost conditions can be a positive factor facilitating the conduct of mining operations. Frozen ground is characterized by quite high mechanical strength, which increases the bearing capacity of pillars and the stability of the mine roof. It may be feasible to mine coal at

Wainwright with no roof bolting or only spot bolting; for conservatism though, a full bolting pattern is assumed. Permanently frozen ground is essentially impervious to gas flow so problems attributable to methane are expected to be minimal.

Provided the mine is kept in its frozen state, the only potential source of water underground will be from surface melt at the portal and shaft openings. Proper construction and sealing during the summer months should avoid this situation. If an MSHA variance regarding water sprays is not attainable, it may be possible to allay coal dust with a weak antifreeze/water solution. The planned upslope panel development will be beneficial in that drainage will occur away from the face. Any spray mixture can then be collected in a sump positioned in the lowermost (fresh air) main entry for pumping and disposal at the surface.

Another operational procedure which may possibly be modified because of the cold mine temperature is rockdusting. A federal regulation requires all underground mines to coat exposed coal surfaces with pulverized limestone. Thus if an explosion occurs at the mine face, the ensuing air wave will not propagate the blast through concentrations of flammable coal dust being shaken from the pillars and ignited. However at Wainwright, it is conceivable that any residual coal dust on the pillars, roof, and walls could simply be frozen into place by the judicious application of a clear water mist. In this analysis the standard rock dusting process has been assumed pending further study.

Figure 4.3.4 presents a preliminary estimate of the development schedule for the coal mine at Wainwright. It presupposes that all regulatory requirements for state and federal agencies have been satisfied, detailed planning has been accomplished, and the construction contractor has been selected. The short shipping season in midsummer must be used, and any dirt work would be performed after the surface soil has refrozen. Table 4.3.4 provides the supporting estimates of time duration and contractor crew size for each construction activity. It appears that the Wainwright mine could be ready for production by February 1 of the year following initial construction.

4.03.5 PRELIMINARY MINE COST ESTIMATE

Based on the foregoing considerations, a capital expenditure schedule, Table 4.3.5, has been prepared to identify expected investment in the mine. (All costs in this analysis are derived as though the mine was located in the conterminous United States. Appropriate multipliers for North Slope conditions will be applied at the end of this section.) Because of the limited planned use for most of the equipment, the operating lives should be greater than normal and are so reflected in the schedule. Proximity to the village of Wainwright and to the generating station has reduced the need for certain equipment items (pickups, etc.) that would normally be included in a capital schedule. As discussed in the footnotes to Table 4.3.5, there is a potential for perhaps $200,000 in savings through select equipment purchases. No contingencies have been included in capital estimating. Initial capital requirements are $1,842,000 for depreciable items ($184 per ton of annual capacity) and slightly over $107,000 for working capital.

Table 4.3.6 presents manpower schedule and costing data. As noted previously, production can be attained by working 80 days per year and annual labor costs have been derived on this basis. The fringe benefits for labor at 20 percent of direct payroll may seem low, but with 285 free days per year there seems to be little reason to schedule holiday work or make provisions for vacations. Labor costs are estimated at $12.92 per ton.

Material and supply costs are detailed on Table 4.3.7; again these are based largely on the amount of time that equipment will be working. Roof bolt and rock dust usage assumes that variances from standard mining practice are not allowed; power costs are attributable largely to the heaters warming intake ventilation air. Material and supply costs are estimated to be $10.70 per ton.

Table 4.3.8 identifies the major costs that will likely be imposed by outside agencies. It is recognized that, because of the ownership and operation of the Wainwright mine by native Americans, certain assessed charges may not be imposed. However all federal charges are presumed in effect in this analysis for conservatism. Under these conditions assessments total $0.65 per ton plus 11 percent of mine realization price.

Table 4.3.9 shows the determination of working capital requirements (included in the capital expenditure schedule) based on 90 days' cash expenditures. These will approximate $107,000. Also on Table 4.3.9 is the depreciation charge analysis; these charges total $10.60 per ton on all invested capital. It is understood that half the capital may be provided as a grant, in which case only half the calculated depreciation should be included as a mining cost.

The estimate of financial charges is given in Table 4.3.10. Provision is made for the 50 percent grant, and interest charges at 8 percent for 20 years on the remaining half of the initial depreciable capital. Working capital needs are financed at 8 percent in this analysis as well. Total financing costs are thus $5.64 per ton.

The summary of mining costs for the Wainwright project, assuming a conterminous United States mine location, is given below. At this point it must be noted that a return on invested capital has not been included in the schedule; under this assumption the transfer price from mine to generating station would be just sufficient to cover all identifiable mine costs.

CONTERMINOUS U.S. MINE LOCATION

Item	Cost, $/ton
Labor	12.92
Material & Supplies	10.70
Assessments	5.00
Depreciation	5.30
Financing	5.64
Total Cost	39.56

A straightforward factoring approach is used to convert the above estimated mine costs to a North Slope situation. The best approximation at this time indicates that a 150 percent factor be applied to capital cost items (and those unit costs related to capital investment) whereas operating costs should be doubled. Using this factoring approach, the following mining costs might realistically be expected at Wainwright:

WAINWRIGHT, ALASKA MINE LOCATION

Item	Cost,$/ton
Labor	25.84
Material & Supplies	21.40
Assessments*	8.65
Depreciation	7.95
Financing**	8.88
Total Cost	72.72

* $0.65 of this amount is not subject to factoring because of location.

** Depreciable capital financing component increases by 150 percent; working capital component increases by 200 percent.

Total invested capital to get the Wainwright mine in operation would approach $2,763,000 for depreciable assets and $214,000 for working capital, or $2,977,000 in total.

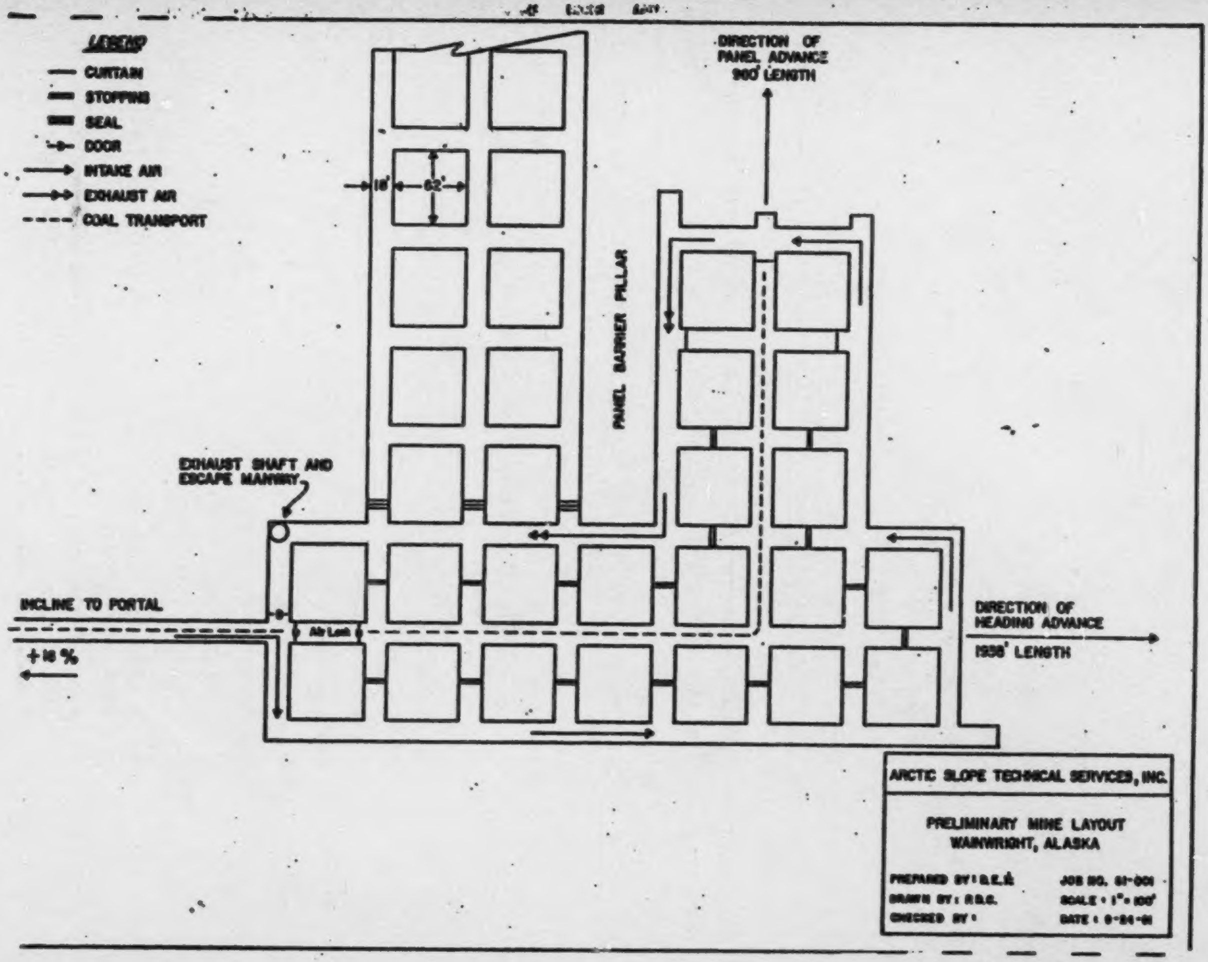
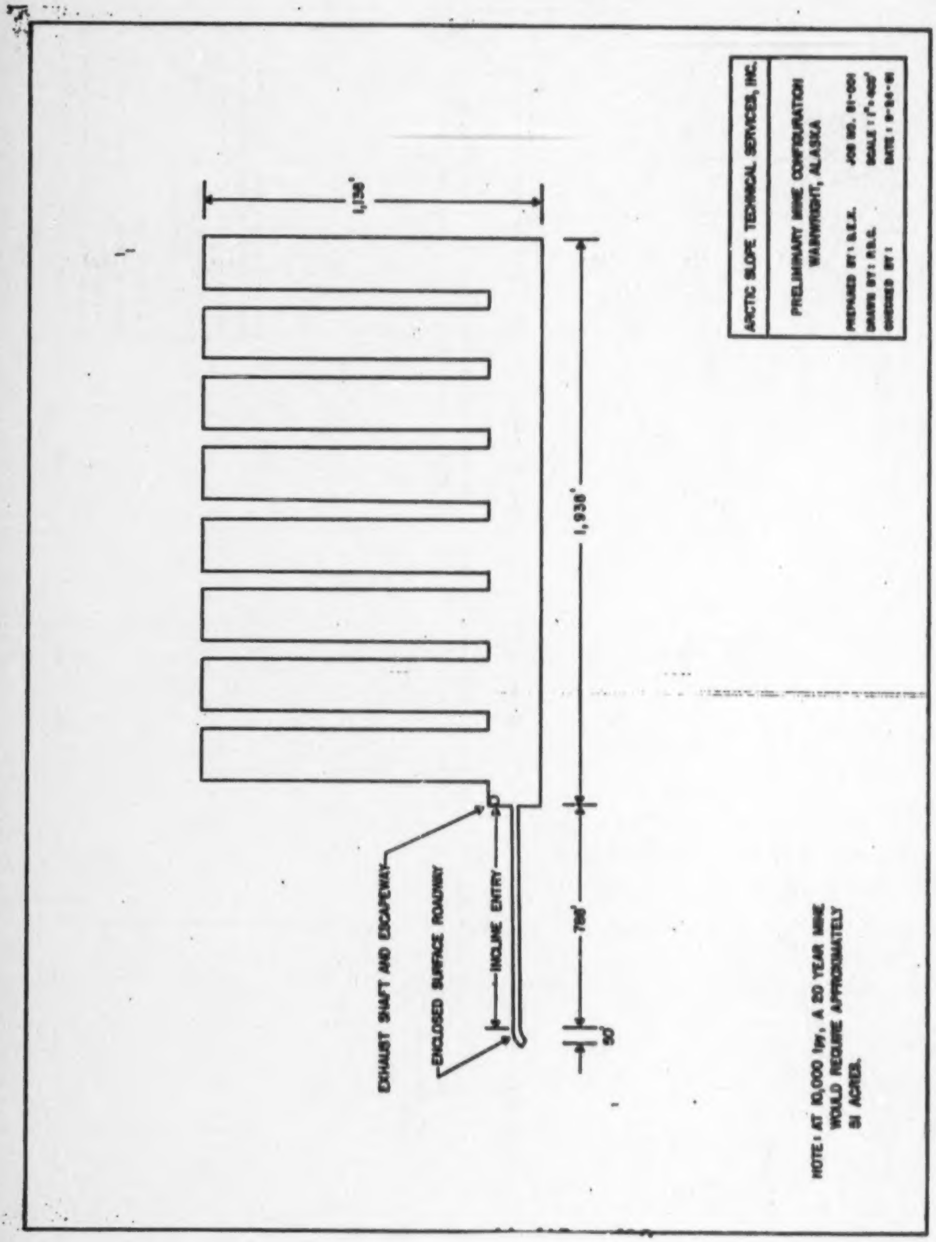

LEGEND
CURTAIN
STOPPING
SEAL
DOOR
INTAKE AIR
EXHAUST AIR
COAL TRANSPORT
18'
62'
PANEL BARRIER PILLAR
DIRECTION OF
PANEL ADVANCE
900' LENGTH
EXHAUST SHAFT AND
ESCAPE MANWAY
INCLINE TO PORTAL
+10 %
Air Lock
DIRECTION OF
HEADING ADVANCE
1938' LENGTH
ARCTIC SLOPE TECHNICAL SERVICES, INC.
PRELIMINARY MINE LAYOUT
WAINWRIGHT, ALASKA
PREPARED BY: D.E.B.
DRAWN BY: R.D.C.
CHECKED BY:
JOB NO. 81-001
SCALE: 1" = 100'
DATE: 8-24-81

FIGURE 4.3.1


1,138'
1,938'
786'
50'
EXHAUST SHAFT AND ESCAPEWAY
ENCLOSED SURFACE ROADWAY
INCLINE ENTRY
ARCTIC SLOPE TECHNICAL SERVICES, INC.
PRELIMINARY MINE CONFIGURATION
WAINWRIGHT, ALASKA
PREPARED BY: S.E.K.
DRAWN BY: R.B.E.
CHECKED BY:
JOB NO. 81-001
SCALE: 1" = 400'
DATE: 9-24-81

NOTE: AT 10,000 t/y, A 20 YEAR MINE WOULD REQUIRE APPROXIMATELY 51 ACRES.

FIGURE 4.3.2

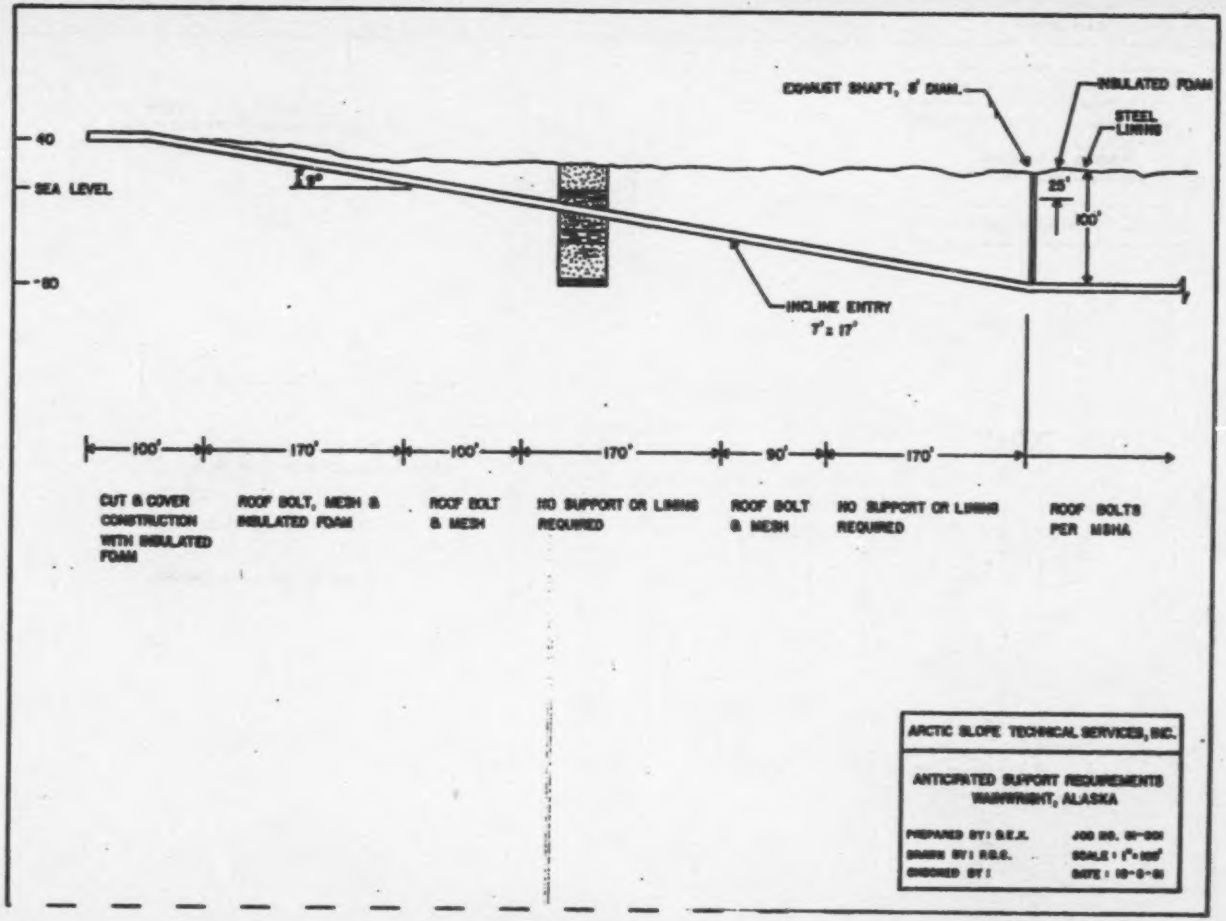
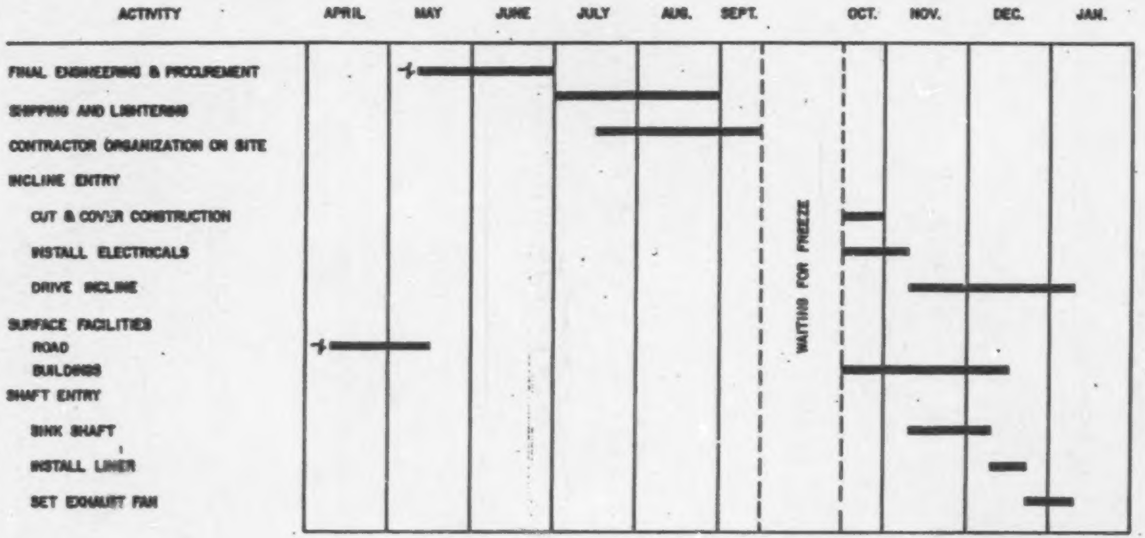

40
SEA LEVEL
-80
9°
EXHAUST SHAFT, 8' DIAM.
INSULATED FOAM
STEEL LINING
25'
100'
INCLINE ENTRY 7' x 17'
100'
170'
100'
170'
90'
170'
CUT & COVER CONSTRUCTION WITH INSULATED FOAM
ROOF BOLT, MESH & INSULATED FOAM
ROOF BOLT & MESH
NO SUPPORT OR LINING REQUIRED
ROOF BOLT & MESH
NO SUPPORT OR LINING REQUIRED
ROOF BOLTS PER MSHA
ARCTIC SLOPE TECHNICAL SERVICES, INC.
ANTICIPATED SUPPORT REQUIREMENTS
WAINWRIGHT, ALASKA
PREPARED BY: S.E.K.
DRAWN BY: R.G.S.
CHECKED BY:
JOB NO. 81-001
SCALE: 1"=100'
DATE: 10-8-81

FIGURE [illegible]



* ASSUMES ALL REQUISITE PLANS HAVE BEEN APPROVED BY VARIOUS STATE AND FEDERAL REGULATORY AGENCIES AND ALL PERMITS HAVE BEEN OBTAINED.

ARCTIC SLOPE TECHNICAL SERVICES, INC.

MINE DEVELOPMENT SCHEDULE *
WAINWRIGHT, ALASKA

PREPARED BY: D.E.K.
DRAWN BY: R.D.S.
CHECKED BY:

JOB NO. 81-005
SCALE: NONE
DATE: 10-9-81

FIGURE 4.3.4

TABLE 4.3.1

UNDERGROUND MINE

Coal Recovery Calculations

MAINS:

Recovery per 80 feet of advance =
3 x 80 ft. x 18 ft. + 2 x 62 ft. x 18 ft. = 6,552 sq. ft.

Total area per 80 feet of advance =
80 ft. x 178 ft. = 14,240 sq. ft.

Recovery = $\frac{6,552}{14,240}$ = 46%

PANELS:

Recovery per 80 feet of advance =
3 x 80 ft. x 18 ft. + 2 x 62 ft. x 18 ft. = 6,552 sq. ft.

Total area per 80 feet of advance =
80 ft. x (178 ft. + 62 ft.) = 19,200 sq. ft.

Recovery = $\frac{6,552}{19,200}$ = 34%

Note: Pillar recovery on retreat is not contemplated at this property, but is possible, especially with ice backfilling. It may also be possible to reduce pillar size once the mine is in operation and ground conditions can be observed.

Mine Dimension Calculations

Panel length: 80 ft. x 12 = 960 ft.

Panel width: (3 x 18 ft.) + (2 x 62 ft.) + (62 ft. barrier pillar) = 240 ft.

Panel area: 960 ft. x 240 ft. = 230,400 sq. ft.

Recovery at 34%: 230,400 sq. ft. x 34% x 6.5 ft. height x 80 pcf ÷ 2,000 lb./ton = 20,367 tons of recoverable coal per panel

TABLE 4.3.1 (Continued)

Length of mains per panel = 240 ft.

Width of mains per panel = 178 ft.

Area of mains per panel = 240 ft. x 178 ft. = 42,720 sq. ft.

Recovery at 46%: 42,720 sq. ft. x 46% x 6.5 ft. height x 80 pcf ÷ 2,000 lb./ton = 5,109 tons of recoverable coal in mains per panel

Total recoverable coal per panel:
20,367 tons + 5,109 tons = 25,476 tons

Production years per panel: $\frac{25{,}476 \text{ tons}}{10{,}000 \text{ tpy}} = 2.55$ years

Mine size:

Production for 20 years = $\frac{20}{2.55}$ = 8 panels

Mine size = (960 ft. + 178 ft.) x (1,920 ft. - 62 ft. + 80 ft.) = 1,138 ft. x 1,938 ft. plus incline = approximately 51 acres

Incline at 16% and 126 ft. deep = 788 ft. (to bottom of seam)

TABLE 4.3.2

UNDERGROUND MINE
Ground Support Material and Supply Calculation

Incline Entry:

7 ft. high x 17 ft. wide
Area = 119 sq. ft.
Wall and Roof Perimeter = 31 ft.

Metal Lining: 100 ft. long x 31 ft = 3,100 sq. ft.
Foam Insulation: 270 ft. long x 31 ft. x 1/2 ft. thick = 4,200 cu. ft.
Roof Bolts: (4-ft. bolts on 4-ft. centers) = 360 bolts
Wire Mesh: 17 ft. width x 360 ft. + 10% overlap = 6,800 sq. ft.

Shaft:

8 foot diameter
Area = 50 sq. ft.
Perimeter = 25 ft.
Metal Lining: 120 ft. long x 25 ft. perimeter = 3,000 sq. ft.
Foam Insulation: 25 ft. of depth x 25 ft. perimeter x 0.5 ft. thick = 315 cu. ft.

Main Entryways:

6.5 ft. high x 18 ft. wide
Area = 117 sq. ft.
Lined Perimeter = 30 ft.
Roof Bolts: (4-ft. bolts on 4-ft. centers = 1 bolt/ft. of drift length)
Annual feet of main entry = 10,000 tpy x 2,000 lbs./ton ÷ 80 pcf ÷ 177 sq. ft. of advance = 2,140 ft. of drift. Bolt usage = 2,140 per year at 10,000 tpy.

TABLE 4.3.3

UNDERGROUND MINE
General Assumptions and Calculations

Basic Data:

Cover depth:	120 ft.±
Coal thickness:	6.7-7.0 ft.
Haul Distance:	4,500 ft.
Entry slope:	16%
Slope dimensions:	7 ft. x 17 ft.
Production rate:	10,000 tons/year
Production period:	October through May
Density of Coal:	80 lb./ft.^{3} in place 55 lb./ft.^{3} broken
Shaft dimension:	8 ft. diameter

Calculations:

Monthly production rate: 10,000/8 = 1,250 tons/month

Daily production rate (on a 10 day/month basis): 1,250/10 = 125 tons/day

Heading width: 18 ft.

Total tonnage/ft of advance: 18 x 6.5 x 1 x 80 ÷ 2,000 = 4.68 tons

Daily advance required: 125 ÷ 4.68 = 26.7 feet

Length of decline entry: 126 ÷ .16 = 788 ft. (to bottom of seam)

Transportation cycle time: (coal haulage)

Initial mining at base of decline

Ramp @ 2.5 mph x 750 ft. = 3.4 min.
Outside @ 6.0 mph x 4,500 ft. = 8.5 min.
10.9 min. one way travel
x 2
21.8 min. round trip travel

Loading time 3.5 min.
Dumping time 1.0 min.
26.3 min.

Average Mining in early years

Add 1,500 ft. internal mine
haulage @ 5 mph = 3.4 min. one way
x 2
6.8 min. round trip

Total average cycle = 33.1 min.

Assume 390 minutes or 6.5 working hours/day = 11 cycles/day

Transporter size required: 11.4 tons Use 14 ton Ramcar

TABLE 4.3.3 (Continued)

Ventilation requirements

Excavator: 3,000 CFM minimum air requirement at the face for this electric unit

Bolter:
3,000 CFM required, similar to the excavator
6,000 CFM; however MSHA regulations stipulate at least 9,000 CFM delivered to the intake end of a pillar line
9,000 CFM

Hauler:
5,000 CFM required for the diesel engine
14,000 CFM minimum required air quantity
+6,000 CFM to counteract lack of sprays
20,000 CFM
x 2 to consider leakage, losses, etc.
40,000 CFM Total

Air velocity check: $V = Q/A$

Intake entry area: $6.5 \times 18 = 117$ ft.^{2}
$V = 40,000 \div 117 = 341$ ft./min. $= 3.9$ mph

Exhaust shaft area $= (4)^2 = 50$ ft.^{2}
$V = 40,000 \div 50 = 800$ ft./min. $= 9.0$ mph

Personnel will be exposed to the 3.9 mph air stream which should present no undue chilling even at a 20°F ambient temperature

Air heating calculations

Mean January temperature	-20°F
Average minimum January temperature	-50°F
Ambient mine air temperature	20°F

Assume a 10° temperature change will consume 2.2 Btu/lb. of dry air for temperatures below 32°F (100 gm H_2O per lb. of dry air basis)

Assume specific volue of dry air = 13.5 ft.^{3}/lb.

$$\text{Weight flow rate} = \frac{60 \times 40,000}{13.5} = 177,777 \text{ lb. of dry air/hr.}$$

Heat requirements at mean temperature difference =
$40/10 \times 2.2 \times 177,777 = 1,564,000$ Btu/hr.

Heat requirements at maximum temperature difference =
$70/10 \times 2.2 \times 177,777 = 2,738,000$ Btu/hr.

Since 1 kW hr. = 3412 Btu, the power needed for heating the intake ventilation air will be in the range of 460-800 kW

TABLE 4.3.3 (Continued)

Building Requirements:

Shop/Warehouse:	3 bays for overnight parking of diesel equipment, and normal maintenance and storage 30 ft. x 90 ft. =	2,700 ft.^{2}
Admin./Changehouse:	3 offices, secretarial space, and 10-man shower facilities 30 ft. x 50 ft. =	1,500 ft.^{2}
Diesel Storage:	including outside dock 30 ft. x 20 ft. =	600 ft.^{2}
		4,800 ft.^{2}

TABLE 4.3.4

UNDERGROUND MINE
Construction Time and Crew Size Calculation

Decline Entry:

Organize crew; rip and doze 50 linear feet of decline, erect 100 feet of liner shell, apply foam insulation.

Crew size: 5 Duration: 2 weeks

Install mine transformers, extend electrical facilities, install mine ventilation heaters, install transformer for exhaust fan.

Crew size: 4 Duration: 3 weeks

Drive 700 feet of 16 percent decline, install appropriate lining and ground support.

Crew size: 7 Duration: 8 weeks

Total Decline: 78 man-weeks

Shaft Entry:

Sink 8-foot diameter shaft from the surface to approximately 100-foot depth using two drills, hand mucking, crane hoist.

Crew size: 5 Duration: 4 weeks

Install shaft liner, ladders, platforms, and apply foam insulation. Construct sun shade.

Crew size: 5 Duration: 2 weeks

Construct fan base, install fan, hood, ducting, and blowout doors.

Crew size: 5 Duration: 2 weeks

Total Shaft: 40 man-weeks

TABLE 4.3.4 (Continued)

Surface Facilities:

Construct road from Wainwright to the mine site. Construct foundations and erect 4800 square feet of facilities, including electricals, plumbing, and equipment. (Road must be constructed before thaw season.)

Crew size: 10 . Duration: 8 weeks

Total Surface: 80 man-weeks
(less if road built by others)

Summary:

Maximum contract personnel on site: 22

Total contractor requirements (including 8 man-weeks receiving shipments): .206 man-weeks

Total contract labor costs estimated at $350/man-day. (This average charge includes ownership and operating costs for associated light equipment.)

206 man-weeks x 5 days per week x $350 per day = $360,500*

* Lower 48 costs in 1981 $

TABLE 4.3.5
UNDERGROUND MINE
Capital Costs - Lower 48
3rd Quarter 1981 $

ITEM	Life In Years	No. of Units	Unit Cost $	Total Cost $	Year -2	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	TOTAL
UNDERGROUND MINING EQUIPMENT																						
Dosco Dintheader	20	1	400,000*	400,000		400,000										200,000***						600,000
Long Airdox LRB 13A Bolter	20	1	44,000**	44,000		44,000										22,000***						66,000
Jeffrey 4114 Ramcar	20	1	185,000	185,000		185,000										93,000***						278,000
SUPPORT EQUIPMENT UNDERGROUND																						
Joy 4226 Exhaust Fan	20	1	32,000	32,000		32,000																32,000
Trane Air Heaters	20	2	23,000	46,000		46,000																46,000
MSA miscellaneous items: mine lamps, self rescuers, fire extinguishers, methanometers, roof jacks, rock duster	5	lot	20,000	20,000		20,000					20,000					20,000					20,000	80,000
Joy 2367 Auxiliary Fan	10	1	9,000	9,000		9,000										9,000						18,000
SUPPORT EQUIPMENT SURFACE ****																						
Caterpillar D-7	10	1	200,000	209,000		209,000																209,000
TOTAL EQUIPMENT				945,000		945,000					20,000					344,000					20,000	1,329,000
BUILDINGS & SURFACE FACILITIES																						
Mine Shop/Warehouse, 2,700 ft.^{2}	20	1	45/ft.^{2}	122,000		122,000																122,000
Admin./Changehouse, 1,500 ft.^{2}	20	1	40/ft.^{2}	60,000		60,000																60,000
Diesel Storage/Dock, 600 ft.^{2}	20	1	25/ft.^{2}	15,000		15,000																15,000
Road, 4,500 ft.	20	1	20/ft.	90,000		90,000																90,000
Powerline 4,500 ft. Transformer	20	1	10/ft.	45,000		45,000																45,000
PRE-PRODUCTION DEVELOPMENT																						
Incline Entry, 750 ft.	20	1	300/ft.	225,000		225,000																225,000
Shaft, 100 ft.	20	1	1400/ft.	140,000		140,000																140,000
Engineering & Permitting	20	lot	200,000	200,000	150,000	50,000																200,000
TOTAL FACILITIES & DEVELOPMENT				897,000	150,000	747,000																897,000
TOTAL CAPITAL EXPENDITURES				1,842,000	150,000	1,692,000					20,000					344,000					20,000	2,226,000
WORKING CAPITAL*****							107,200															107,200
TOTAL CAPITAL INVESTMENT					150,000	1,692,000	107,200				20,000					344,000					20,000	2,333,200

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* This is the cost of a new unit; however, Kaiser's Sunnyside, Utah mine has an unused Dintheader which probably could be acquired for less than $200,000.

** A worst case situation is implied by the purchase of a separate bolter; Dosco can adapt a small drill to operate from the Dintheader hydraulic system, which should be sufficient for the planned operation at Wainwright.

*** A major overhaul, costing half the original purchase price, is suggested for the primary pieces of mining equipment at this time.

**** A front-end loader that would work from the stockpile is presumed a part of the plant capital; miscellaneous items normally included, such as pickups, are probably not mandatory at Wainwright.

***** Working capital will be returned in year 20.

TABLE 4.3.5A

UNDERGROUND MINE

ESTIMATED WAINWRIGHT COSTS* 3rd QUARTER 1981 $

YEAR	AMOUNT
-2	225,000
-1	2,538,000
1 (first production)	214,400
5	30,000
10	516,000
15	30,000
TOTAL	3,553,400

* Capital costs estimated at lower 48 costs (Table 4.3.5) times 1.5. Working capital estimated at lower 48 costs times 2.0.

TABLE 4.3.6

UNDERGROUND MINE

Manpower Schedule and Annual Costs
Lower 48 Costs, 3rd Quarter 1981 $

Classification	Daily Wage Rate, $	Total Personnel	Annual Labor Costs, $*
HOURLY LABOR			
Miner Operator	95	1	7,600
Miner Helper	91	1	7,300
Bolter Operator	95	1	7,600
Transport Operator	88	1	7,000
Utility Man	85	2	13,600
Ventilation	85	1	6,800
Maintenance	95	2	15,200
General	85	2	13,600
		11	78,700
SALARIED STAFF			
Mine Foreman		1	14,000
Warehouse & Supply		1	9,000
Accounting & Payroll		1	6,000
		3	29,000
TOTAL MINE DIRECT LABOR		14	107,700
FRINGE BENEFITS @ 20%			21,500
TOTAL MINE LABOR COSTS			129,200
Unit Labor Costs			12.92/ton

* Based on 1/3 time, or 80 operating days/year

TABLE 4.3.7

UNDERGROUND MINE

Material & Supply Costs
Lower 48 Costs, 3rd Quarter 1981 $

EQUIPMENT

Item	Annual Usage*	Unit Cost**	Annual Cost, $
Dosco Dintheader	320 hr.	44.00/hr.	14,100
Long Airdox Bolter	320 hr.	4.00/hr.	1,300
Jeffry Ramcar	640 hr.	16.70/hr.	10,700
Joy Fans	640 hr.	0.30/hr.	200
Trane Heater	640 hr.	0.60/hr.	400
Caterpillar Dozer	480 hr.	25.10/hr.	12,000

* Estimated equipment running time
** Repairs and Replacements

BUILDINGS & SURFACE FACILITIES			
Mine Shop/Warehouse		5% Initial cost	6,100
Admin./Changehouse		5% Initial cost	3,000
Diesel Storage/Dock		5% Initial cost	800
Road		10% Initial cost	9,000
Powerline		5% Initial cost	2,200
MISCELLANEOUS SUPPLIES			
Roof Bolts	2,140	3.30 ea.	7,100
Rock Dust	50 tons	30.00/ton	1,500
Concrete Block	1,000	0.60 ea.	600
Fuel	8,000 gal.	1.25/gal.	10,000
Power	700,000 kW-hr.	0.04/kW-hr.	28,000 *
TOTAL MINE MATERIAL & SUPPLY COSTS			107,000
Unit Material & Supply Costs			10.70/ton

* The unit cost of 0.04 per kwh is far too low. However, since heating of the ventilation air will not be done by electricity, but by hot fluid from the Central District Heating System, the cost will not materially exceed that shown.

TABLE 4.3.8

UNDERGROUND MINE

Estimate of Assessments
3rd Quarter 1981 $

1. Black Lung Tax: 2% of mine realization price, not to exceed $0.50/ton. At Wainwright the maximum assessment will be used.

2. Reclamation Tax: $0.15/ton for underground coal.

3. Royalties: Federally owned, deep mined coal carries an 8% royalty based on mine realization (selling) price. At Wainwright, because of the captive nature of the proposed mine/generating station, the transfer price may be just the actual cost/ton without consideration of a normal return on investment.

4. Severance Tax: The state of Alaska does not currently impose a severance tax on coal although considerable discussion is centering on a proposed levy amounting to 3% of mine realization price. The state does have a mining license tax that is imposed on a sliding scale from 2-7.5% of net profits, the maximum rate being applied on net profits in excess of $100,000. Enactment of a severance tax would negate the mining license levy. In this analysis the 3% severance tax will be used.

5. North Slope Borough Tax: This is a tax applied to property improvements with the beneficiaries being the natives. Since this mine will be operated by the natives for their own benefit, there seems to be no point in assessing this tax.

Total Assessments: $0.65/ton* plus 11% of mine realization price

* No adjustment will be required for North Slope conditions.

TABLE 4.3.9

UNDERGROUND MINE

Working Capital Requirements
Lower 48 Costs, 3rd Quarter 1981 $
(90 days out-of-pocket expenses,
or 3750 tons of production)

Supervisory & Professional Staff	$ 13,000
Operating & Maintenance Personnel	35,400
Material & Supply Costs	40,100
Assessments	18,700
	$107,200

Depreciation Charges
(Straight Line Basis)

Item		Total Cost, $	Depreciation Cost/Ton
5-year life:	Miscellaneous	20,000	$ 0.40
10-year life:	Auxiliary fan, dozer	218,000	2.18
20-year life:	Mining equipment, surface facilities pre-production development	1,604,000	8.02
			$10.60

The $10.60/ton charge represents straight line depreciation on total wasting investment. If the project obtains 50% of its capital needs in the form of a grant, only half, or $5.30/ton, should be included as a cost of mining.

TABLE 4.3.10

UNDERGROUND MINE

Estimate of Financial Charges
Lower 48 Costs, 3rd Quarter 1981 $

Assumptions:

In this study it is assumed that 50% of the capital needs for the project will be obtainable as a grant, and that the remaining 50% will require repayment, together with interest charged at 8%.

Calculations:

The function of depreciation in a business venture is a recognition of the wasting nature of assets, and when included in the sales price of a product, allows the owner to collect over time sufficient money to replace the asset when required. In this sense it is a repayment of capital without interest. Since depreciation is included as a cost item, only the associated interest charges need be calculated.

The approach here has been to determine an annual annuity payment to retire the principal and pay interest, multiply this figure by 20 to cover the 20-year life of the project, then subtract the beginning capital. The remaining figure is pure interest which can then be allocated to each ton produced. As the working capital will be returned at the project's close, just straight annual interest charges need be determined for this portion of investment.

Total Depreciable Capital:	$1,842,000
Amount subject to financing	921,000
Annuity to repay over 20 years at 8%	93,800
Total payments over 20 years	1,876,000
Less Principal	921,000
Total Interest on Depreciable Capital	$ 955,000
Total tonnage Produced	200,000 tons
Interest charge/ton	$4.78

TABLE 4.3.10 (Continued)

Total Working Capital	$107,200
Annual interest at 8%	8,600
Annual tonnage produced	10,000 tons
Interest charges/ton	$0.86
Total Financing Charges	$5.64/ton

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4.05.0 MANUFACTURERS & SUPPLIERS

Dosco Corporation
Denver, Colorado
(303) 321-5597
David Neil

Banderet Equipment Company
Denver, Colorado
(303) 289-5793
John Burnell

Jeffrey Mining Machinery Div.
Columbus, Ohio
(614)297-3123
John Smith

U.S. Gypsum, Metal Products Div.
Chicago, Illinois
(312) 321-5860
John Szabo

Martin-Trost Associates
Golden, Colorado
(303) 279-4255
Bill Martin

The Trane Company
Denver, Colorado
(303) 779-0787
Lyle Breshears

Wagner Equipment Company
Portland, Oregon
(503) 255-2863
Harold Kammerzell

Long-Airdox Company
Salt Lake City, Utah
(801) 637-3236
Jim Diamanti

Joy Manufacturing Company
Denver, Colorado
(303) 388-5891
Bob Smith

Safe Lok Systems, Inc.
Denver, Colorado
(303) 761-1820
Jim Farrell

Mountain States Machinery
& Supply
Price, Utah
(801) 637-1434
Chuck Buchanan

Alaska Department of
Natural Resources
Anchorage, Alaska
(907) 276-5113
David Hedderly-Smith

APPENDIX A

Supporting Documentation

1. "Permafrost Tunneling by a Continuous Mechanical Method" by George K. Swinzow
2. "Tunneling in Permafrost, II" by George K. Swinzow

448

PERMAFROST TUNNELING BY A CONTINUOUS MECHANICAL METHOD

George K. Swinzow

November 1970

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CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

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PERMAFROST TUNNELING BY A CONTINUOUS MECHANICAL METHOD

by

George K. Swinzow

INTRODUCTION

urpose

This research was part of an effort to investigate methods of subsurface excavation for nilitary installations in perennially frozen ground. Special emphasis was given to studies of the ermafrost, its interaction with man's underground activity, and the properties of the tunnels, such as deformation, natural air flow, feasible types of ventilation, and the thermal regime.

For the purpose of this paper, permafrost is defined as unconsolidated soil such as alluvium, noraine, sand, silt or gravel deposits cemented by ice. As long as it is frozen it may be very similar to such rocks as conglomerate, sandstone, siltstone, etc. Usually the pore ice cement emains solid to temperatures very close to 0C.

The capacity of permafrost to absorb high velocity shocks without excessive shattering is attractive for military purposes (research on this is presently in progress). Roofs of tunnels and ooms excavated in permafrost are easily made safe and are relatively stable under explosive shock oads. Relative ease of excavation and the fact that the internal temperature is always appreciably higher than the air temperature during the arctic and subarctic winter mean that tunnels in permarost are effective weather shelters.

Over the years man has developed three methods of frozen ground excavation: steam points, high pressure water jets, and explosives, used in hard rock tunneling. The explosives method was applied, tested and modified for use in permafrost during a special research program in Greenland (Abel, 1960; Swinzow, 1964).

Excavating a test tunnel in permafrost and studying the continuous mechanical tunneling method in this environment were the prime objectives of this study. A further objective was evaluation of the subsurface opening as a shelter, storage space, and site for military activity. Further, the tunnel provided opportunities to conduct geological, paleogeographical and rheological studies of an important type of permafrost. This report concentrates mainly on the tunneling method, the process of cutting frozen ground, and some general properties of the tunnel.

Mining classification of permafrost

Tunneling in "warm" unfrozen rock is a highly developed art. The engineer confronted with such a task may confidently predict costs and time, depending upon the type of strata, lithology and ground water conditions. However, relatively little is known about tunneling in permafrost.

To establish a "first generation" basis for planning an excavating, mining or tunneling operation in permafrost, we may regard two aspects of it: 1) properties to expect in any permafrost regardless of composition, and 2) properties of the particular permafrost deposit to be worked, such as ice content, mechanical composition of constituent minerals, and temperature.

In general the mining engineer can expect no water problem as long as tunneling proceeds in the frozen layer (not at its top or bottom). He will encounter temperatures below the melting point that fluctuate only slightly over the seasons. He may expect the winter temperature to be considerably lower outside than in the tunnel.

The particular deposit of permafrost may affect the excavation by having more or less ice cement, more or less coarse soils and boulders, and lower or higher temperatures. All these factors affect the operation and must be known in advance.

To predict difficulty and the extent of needed effort, one may begin by setting up a classification framework. The proposed classification (Table I) is based on arbitrarily set boundaries of the three main parameters: temperature, ice content and mechanical composition.

Table I. Mining engineer's classification of permafrost (proposed).

Temperature	*Ice content*	*Size of material*
Cold -7 to -10C (19 to 14F)	High	Fine
		Coarse
	Low	Fine
		Coarse
Intermediate -4 to -7c (25 to 19F)	High	Fine
		Coarse
	Low	Fine
		Coarse
Warm -0.5 to -4C (31 to 25F)	High	Fine
		Coarse
	Low	Fine
		Coarse

The arbitrary parameters are arranged in three columns in the order in which they cause increasing difficulties. The first column begins with cold permafrost and ends with warm permafrost. The limits are -10C, a temperature to be expected at very few sites, and -0.5C, above which hardly any stable permafrost exists. Ice content is regarded in terms of the degree of saturation. Relatively dry permafrost may be excavated more easily than ice-saturated material, but roof stability may decrease with decreasing amounts of ice cement. Furthermore there is the problem of maximum span. It is obvious that in dry permafrost one should allow for less span than in a fully saturated permafrost. The third column reflects the composition. An abundance of boulders, especially metamorphic and igneous material, leads to difficulties of a primary nature, e.g. hard rock drilling and unfavorable powder ratios with overburden. In column 3, the upper item in each temperature range is always the more favorable for excavation.

The table shows that a cold permafrost consisting of fine material strongly cemented by abundant ice is more advantageous than warm, undersaturated material consisting predominantly of large boulders. The table is intended to predict technical difficulties and assist a mining engineer in planning and selecting the excavation method for a given location. For example, a location in the northern archipelago of Canada with cold permafrost with intermediate to high ice content, consisting of predominantly bouldery material, requires modified hard-rock excavation methods such as those described by Swinzow (1964). Roof instability problems are insignificant and can be remedied by application of quick back-freezing slurries. Overbreak and slabbing can be handled similarly. The engineer can probably expect a somewhat higher powder ratio, but he may cross most of the timber and all of the concrete off his list.

At the other extreme is a warm permafrost with low ice content and coarse boulders. There are problems with all engineering features. The rate of advance may become low due to overbreak. An unstable roof requires a large amount of timber work while man and machine are jeopardized by thawing in the roof.

ENVIRONMENT

Location and strata

The site of the Alaska Experimental Permafrost Tunnel is an abandoned gold dredging field. During mining operations the central part of Engineer Creek Valley was stripped of its overburden of perennially frozen silt and the underlying gravel was dredged for gold and dumped in small hills, dry and unfrozen. The edge of the field is a steep, unstable cliff of overburden. At its foot the gravel was smoothed out and a mining camp erected. The portal was constructed in the steep cliff at the boundary of the gold field and the tunnel was driven into the perennially frozen silt (Fig. 1).

The perennially frozen Fairbanks silt, first described by Mertie (1937), is supersaturated and contains large lenses, wedges and veins of ice. The deposit is stratified; streaks of sand (fine and coarse) and gravel are common throughout the tunnel. A distinct characteristic of the tunnel is its odor, derived from partially preserved organic material in the frozen silt. The presence of abundant partially preserved animal and plant material indicates the possibility of syngenetic[*] origin. The microscopic appearance of the silt's fabric is that of an open packing impossible to achieve by ordinary sedimentation. Figure 2 is a polished section of a frozen sample made by a technique similar to that used in metallurgy. The blank portions represent clean ice. Note that the packing is open in the coarser as well as in the clay-size fraction.

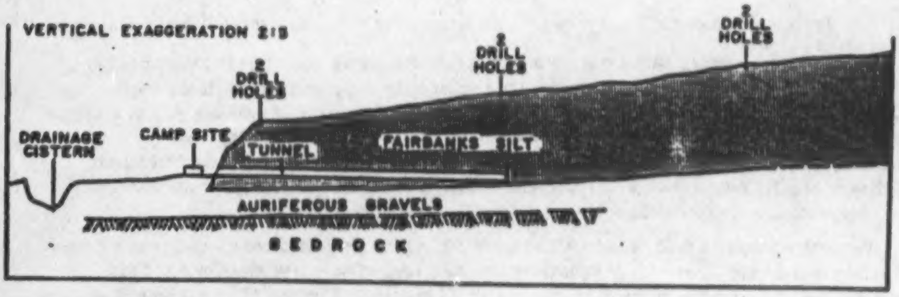

Figure 1. Schematic geological cross section along the axis of the tunnel.

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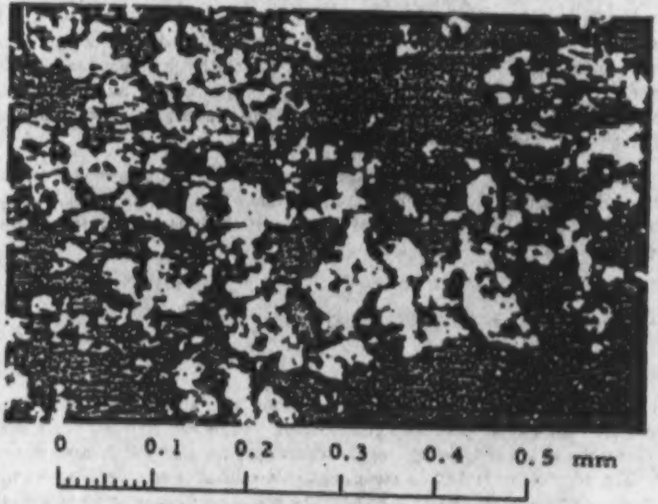
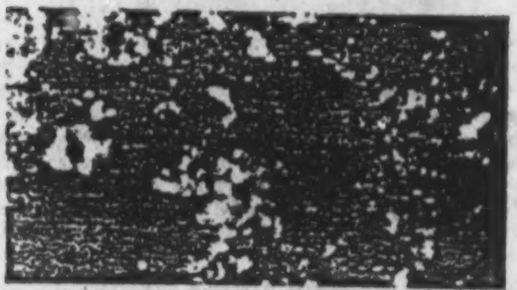
[*] Permafrost formed during deposition.



a. Section with predominantly coarse particles.

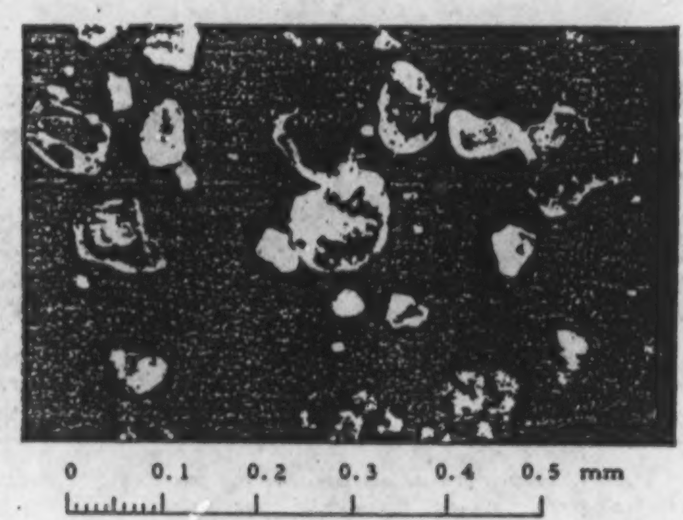


b. Section with mainly fine, clay-size particles.

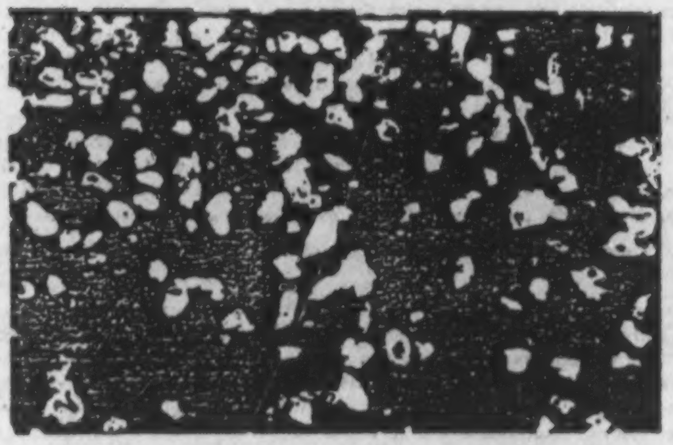
Figure 2. Polished sections of Fairbanks silt photographed in reflected light (Ultropak method).

Figure 3 shows slides of two typical ingredients of Fairbanks silt. The 0.1-mm particles (Fig. 3a) are predominantly micas, such as biotite, muscovite and phlogopite, with only a few other minerals like quartz and the feldspars. Figure 3b, an assemblage of 0.01-mm grains, contains most of the quartz and feldspars with a few other minerals. The grains smaller than 0.1 mm were essentially monomineralic and apparently very little mechanical rounding had occurred (the particles were angular and unweathered). Clay-size material (not illustrated) was mostly sericite mixed with ordinary clay minerals such as montmorillonite and kaolinite.

Vertical exploration drilling, as well as tunneling, disclosed inclusions of stones in amounts increasing with depth. These stony inclusions are, as a rule, of very low sphericity and vary from a fraction of an inch in diameter to cobble size (4 to 7 in.). Figure 4 is an example of an area with large stones. At the time the machine was excavating this area, about 74 ft from the portal, the structure occupied the cutting face, presenting a similar pattern in a plane perpendicular



a. *0.1-mm particle - predominantly micas.*



b. *0.01-mm particle - quartz, feldspars, occasional garnets.*

Figure 3. Microslides of Fairbanks silt (Ultropak illumination).

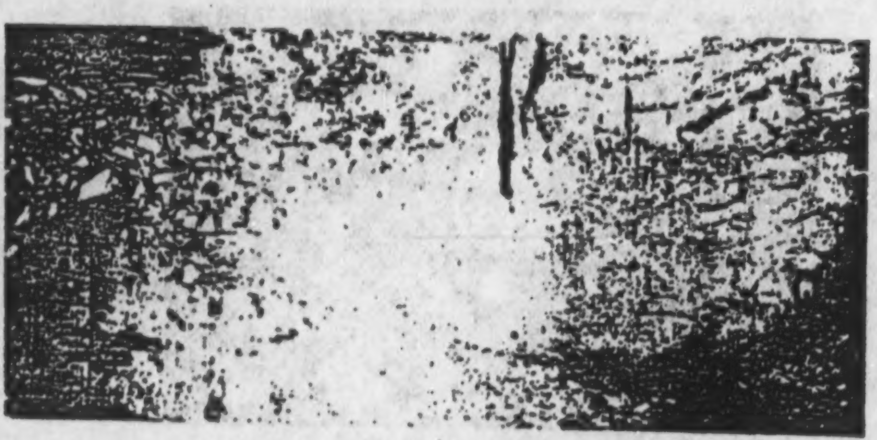


Figure 4. Structure of stone inclusions 74 ft from portal.
Scale in center of photo: 1 in. = 1½ ft (approximately).

to that of the picture. The impression was of an excavated asymmetrical sorted stone polygon of the type described by Corté (1962). The gravel underlying the Fairbanks silt is a very angular, inhomogeneous material with very low sphericity. Generally its appearance is similar to the material exposed in the tunnel (Fig. 4). The Fairbanks silt stratum does not have a sharp lower boundary, but becomes gradually richer in rock fragments. It is possible that the "gravelly" exposures in the tunnel are results of frost action upon the auriferous gravels during the silt deposition.

The exact mode and rate of deposition of the Fairbanks silt cannot be explained satisfactorily. Available literature suggests a variety of origins. Péwé (1955) conducted geological mapping of the area and hypothesizes that the "upland silts" as he calls them were deposited by an eolian process. He includes the process of loess formation in the depositional cycle.

Taber (1943) presents the stratigraphic position of the silt as a whole including its frozen parts.

The permafrost tunnel disclosed strata in the Fairbanks silt indicating discontinuous deposition rates with patterned ground and ice wedge formation. Figure 5 is an example of a probable former "daylight" surface such as is usually displayed by hummocky tundra. Such a formation would be possible only during a break in soil deposition. Numerous ice wedges, autochthonous ice masses and segregation veinlets also indicate interrupted deposition or changes in its rate (Fig. 6). Detailed study of plant remnants in the tunnel may lead to evidence of climatic changes during the deposition of Fairbanks silt. Figure 7a shows a stratum rich in tree-root remnants; Figure 7b shows an ice wedge buried by subsequent deposition.

Thermal environment

Geographically the Fairbanks area is near the southern border of discontinuous permafrost. The mean annual temperature in the area is very close to -3.3C. Freezing weather is remarkably prevalent. Normally a slight excess of days with frost over thawing weather is sufficient for

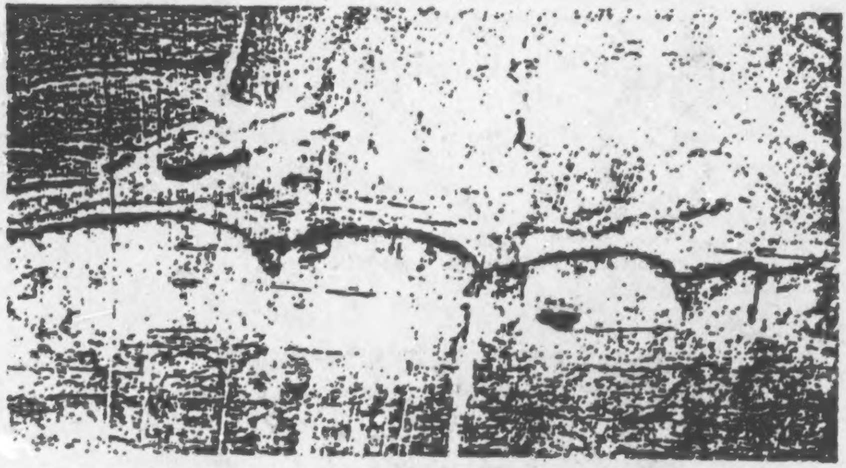
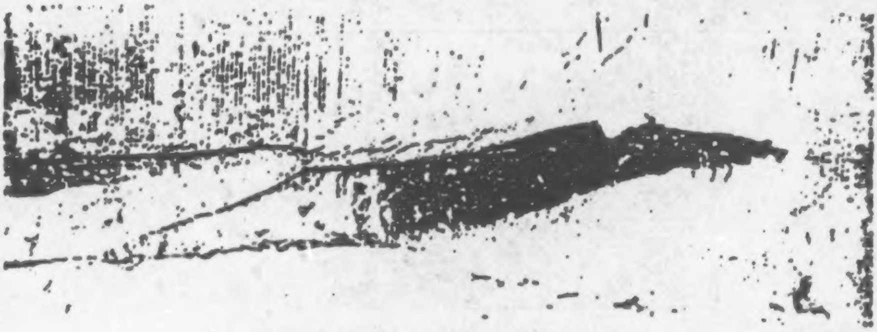


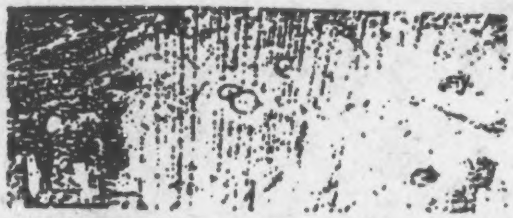
Figure 5. Patterned organic inclusion layer. Probable origin: buried tundra humps.



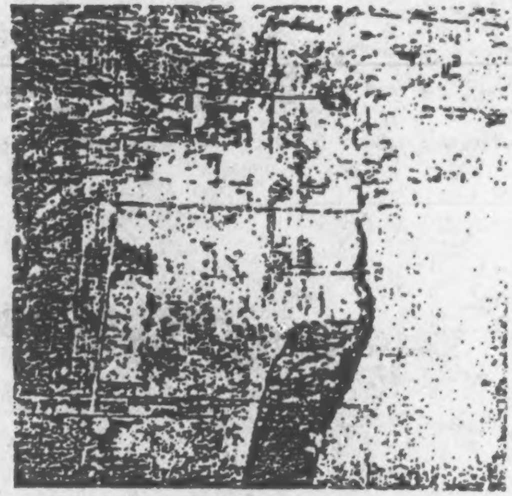
a. 140 ft. Ice inclusion with truncated top.

b. 150 ft. Ice veinlets and flat lens.

Figure 6. Some types of ice appearing in the tunnel.



a. Section at 60 ft. Tree roots preserved in permafrost. Gravelly beds visible in upper left corner.



b. Ice wedge at 124 ft.

Figure 7. Some details of tunnel wall.

permafrost formation. The Fairbanks area has a ratio of freezing degree-days to thawing degree-days of approximately 1.7:1. One would expect to find continuous permafrost with a temperature about the same as the yearly average. On the contrary, the permafrost of the Fairbanks area is warm (minimum temperature around -2C) and discontinuous. One reason for this might be an increased geothermal flux of which there is some evidence in the area. However, as far as could be determined, the geothermal gradient in this region has never been studied with sufficient accuracy to explain an apparent anomaly.

The area is relatively dry – about 30 cm of precipitation per year. The snow cover is up to 100 cm thick.

Physiography

The permafrost in the Fairbanks area is discontinuous. Hills and ridges are as a rule unfrozen; southern slopes are unlikely to have permafrost while the greatest depths are in narrow valley floors. One possible explanation for this is that there are frequent winter thermal inversions in the area. Weather records from Fairbanks as well as from the tunnel site show that when air temperatures at higher elevations are as high as -20 to -30C, valley floors may be at -40 to -50C.

Normally the borderline between permafrost and unfrozen ground is not a simple vertical cut-off. It is either a progressive thickening of the active layer to a point where it only rarely fuses with permafrost at the time of greatest winter frost penetration, or the lower boundary of the permafrost becomes progressively shallower until it reaches the winter depth of freezing.

Preliminary field explorations disclosed both. Moving up the valley slope approximately along the axis of the tunnel, we found, by drilling, a progressive thickening of the seasonal frost layer together with thinning of the perennially frozen layer until both met, which was considered to be a local border of the permafrost area. In some cases there was more than one frozen layer in only a few meters of depth. It is apparent, therefore, that the perennially frozen silt body must be in the form of a concave-convex lens in cross section with neither surface parallel to the topographic profile.

For further discussion concerning details of the tunnel site geology, geomorphology and cryopedology, see Sellmann (1967). McCoy (1964) gives a series of gradation curves reflecting the mechanical composition of the frozen silt as well as the limits of its changes.

SELECTION OF MINING PRINCIPLE

The tunnel site is 11 miles north of Fairbanks near the Steese Highway. The local permafrost is warm (around -1C), fine grained and has a high ice content (up to 65% by volume). Preliminary geological site exploration disclosed possible severe difficulties for the rock drill and a low response to explosives. It was therefore only logical to scrutinize one of the continuous mechanical methods used in the coal industry. Parameters for selection of a suitable machine were to be weight, power requirements, and degree of mobility, together with initial cost. An additional point was the search for some novel principle with an obvious technical advantage.

An extensive survey was made among the existing continuous mechanical mining systems. Six machines were selected for final comparison. Their fundamental properties are summarized in Table II.

On the basis of the data in Table II the Alkirk Continuous Cycle Miner (Fig. 6) was selected. Its relatively low weight constituted a major logistical advantage. Its power consumption was also advantageous, and it employed a novel principle, the so-call "pilot pull principle."

Any continuous mechanical miner must incorporate four functions: 1) locomotion (tramming) to move toward the face; 2) sufficient thrust against the face for the cutting teeth to dig into the material; 3) disintegration of the material at the face by means of continuous motion of the cutting tools; and 4) delivery of the cuttings away from the face to a place where they may be conveyed to the surface.

Table II. Selected properties of six mechanical mining systems.

System	Approx. basic price (1962)	Gross weight (tons)	Remarks
Foundation Co. of Canada	$ 75,000	60	Applied in Toronto in soft shale and limestone. Breakdown reported.
Robbins Cont. Miner	200,000	35 (basic)	Machine successful in soft formations. Large power requirements.
Goodman System (Type 485)	150,000	52	Used successfully in potash mining. Power requirement: 600 hp.
Joy Mfg. System (2BT-2)	150,000	40 (basic)	Machine would need to be redesigned. Requires 600 hp.
Alkirk Pull Principle	150,000	12.5	Machine applies a unique pull principle. Requires 225 hp.
Kirk-Hillman	150,000	est. 30	No record of successful application available. Power requirements unknown.

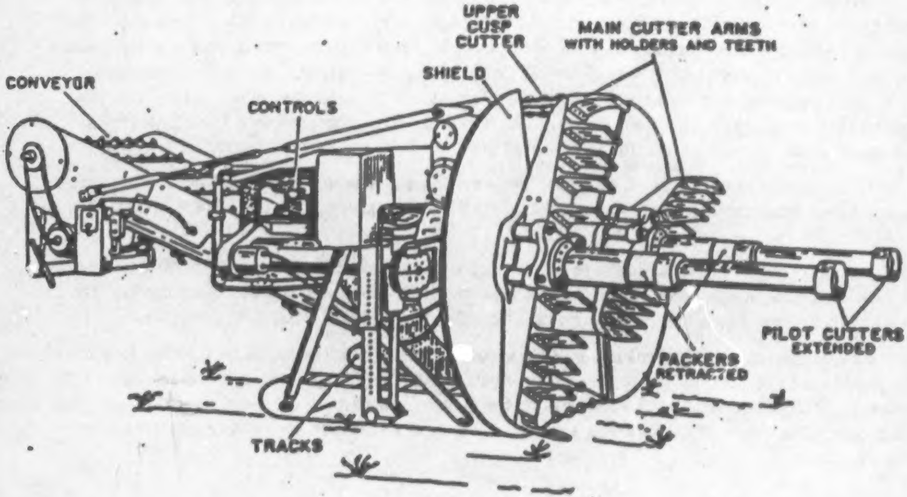

UPPER CUSP CUTTER
MAIN CUTTER ARMS WITH HOLDERS AND TEETH
SHIELD
CONVEYOR
CONTROLS
PILOT CUTTERS EXTENDED
PACKERS RETRACTED
TRACKS

Figure 8. The Alkirk Continuous Miner

To accomplish the second function the Alkirk miner employs the unique twin pilot-pull principle. Two 8-in. pilot cutters drill two anchor holes into the rock face and are fastened into them ahead of the machine. After the pilot holes are drilled and the anchoring packers set, the main cutting arms are engaged and rotate in opposite directions. The machine then moves into the face by pulling against the two anchors. The machine does not rely upon its own weight for forward thrust nor does it need hydraulic wall rams or excess traction force. The two main 7-ft-diam cutting arms rotate on centers 5.5 ft apart so that the circles they scribe on the face overlap. The two cusps left on roof and floor are removed by two arrangements: an upper rigid-axis cusp cutter and a lower cutting link-chain conveyor armed with drag bits. The conveyor also removes the cuttings to the rear of the machine for tramming out.

Below are given some technical data on the machine necessary for further discussion. More details of a functional nature are given by McCoy (1964).

Dimensions:

Diameter of miner cutters	7 ft
Diameter of pilot borers	8 in.
Distance between centers	5 ft 6 in.
Work stroke, maximum	5 ft

Cut dimensions:

Vertical	7 ft
Horizontal	12 ft 6 in.

Drive:

Liquid-cooled electric motor, 200 hp, 1800 rpm, 440 v, 60 cycle, 3 phase explosion proof, 200% overload.

Main cutter drive:

Worm gear type, two speed: 10-and 15-rpm pilot cutter drives.
Hydraulic motor speed about 110 rpm.

Track drive:

Independently controlled hydraulic motor; infinitely variable speed: 0 - 30 rpm forward and reverse.

Conveyor drive:

Electric motor, 25 hp, 440 v, 60 cycle, explosion-proof.

Functional control:

Six hydraulic motors, hydraulic selector-valves, infinite control, pressure checks, reverse flow, two pressures – high and low.

Heat exchanger system:

Oil to oil, oil to antifreeze, antifreeze to air.

TUNNELING OPERATION

Operation of previous seasons

Prior to the main tunneling operation the site was explored, the camp was constructed and a temporary portal was erected for safety, since the steep, unstable man-made slope could reasonably be expected to interfere with the operation.

There was a trial period for the Alkirk Continuous Miner. The trials were conducted in various machine configurations with 2.1 m (7 ft) and 2.4 m (8 ft) main cutter diameters. Both cutting speeds (10 and 15 rpm) and several types of cutting tools were tried. In one case, the teeth were so positioned that the whole tunnel face was cut without leaving any ridges; in another, the teeth were spaced to leave ridges which broke off periodically without the expenditure of cutting energy.

The result of these trials was a 45.5-m (155-ft) tunnel. As far as possible all preliminary observations are incorporated into the present report and may be found under appropriate headings.

Main tunneling operation

Volume of work. In 1965 tunneling began at 45.5 m and proceeded to 110 m (356 ft). Full attention was given to the mining cycle, performance of machine and operator, power use, and the interaction of various elements. The data summarized below were collected on special shift reports. Data on equipment maintenance were collected separately.

Operational cycle. The Alkirk machine is called a continuous-cycle miner. The cycle begins with extension of the pilot tubes and rotational cutting of two pilot holes. The pilot tubes are anchored in their holes by expansion of two packers consisting of massive rubber rings. The actual mining begins with the starting of the inclined conveyor which removes the debris and cuts the lower cusp, starting of the upper cusp cutter together with the main cutting arms, and application of face thrust by a gradual retraction of the anchored packers.

The rock (or in this case, permafrost) cut by the arms, cusp-cutter teeth and lower conveyor falls down directly in front of the face where it is picked up and transported to the rear. The cycle is complete when the pilots are fully retracted; it is then repeated by cutting another pair of pilot holes, etc.

As seen in Figure 8 the cutting tools were extended on special tool holders. This shortened the stroke of the pilots, but was necessary in permafrost as will be evident below. The whole cycle takes about 15 minutes in permafrost, and four such cycles result in 2.4 m of tunnel, provided that all parts function perfectly and haulage capacity is adequate.

The available haulage equipment did not fit under the elevating conveyor and the machine produced more waste than could be removed. But these drawbacks did not detract from the purposes of the research project which were evaluation of the mining method and study of the tunneling process, not efficient production of permafrost tunnel. During the two seasons of operation, it was found that the expansion factor (the ratio of volume of disintegrated material to original volume) was from 2.45 to 3.6, depending upon the amount and configuration of the cutting tools. Most of the tunneling was done in a configuration providing the lower, more advantageous expansion factor. The Joy 10CS-AC Shuttle Car performed well but its capacity of 9 yd^3 was insufficient for one complete cycle and was a source of delay. Attempts to continue mining between haulage trips failed since the expanded loose material, occupying a larger than in-place volume, threatened to bury the machine. Further delays were caused by the need to insert another machine, a Joy 8 BU-AC front loader rated at 1.75 yd^3/min, between the miner and the shuttle car to handle the material removed by the miner.

The whole arrangement of mining equipment in the tunnel is shown schematically in Figure 9. Table III summarizes pertinent haulage data.

Table III. Haulage data

1. Requirements to mine one cycle

Nominal time*	15 min
Tunnel length	0.61 m (2 ft)
Volume of material in place	3.9 m^3 (5.1 yd^3)
Expansion factor	2.45
Volume of material to be moved in one cycle	9.51 m^3 (12.5 yd^3)
Average time to load one shuttle car	6 min
Average time to unload one shuttle car	4 min

2. Ratio of mining time to total operation time

0 ft	0.500
50 ft	0.428
100 ft	0.375
150 ft	0.316
200 ft	0.250
250 ft	0.231
300 ft	0.214
350 ft	0.207

* Time without hauling trip delay.

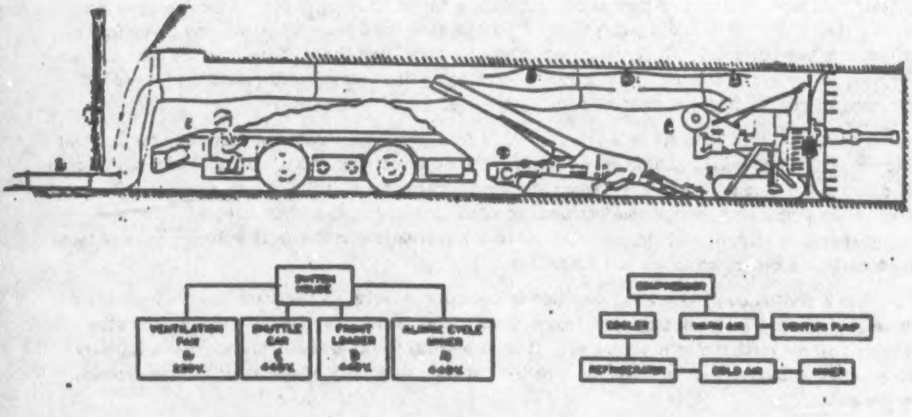

SWITCH HOUSE
VENTILATION FAN
SHUTTLE CAR
FRONT LOADER
ALKIRK CYCLE MINER
COMPRESSOR
COOLER
WARM AIR
VENTURI PUMP
REFRIGERATOR
COLD AIR
MINER

Figure 9. The arrangement of equipment in the tunnel.

Operating the machine required an average of 113.8 kilowatt-hours per linear meter of tunnel (34.7 kwhr/ft). This included all equipment: miner, front loader, shuttle car and ventilation plant. The consumption varied from 82 kwhr/m to 208.3 kwhr/m (25-63.5 kwhr/ft) owing to the need for long warm-up idling of cold equipment or idle run for adjusting and for packer slipping (see below).

All three machines in the tunnel operated on trailing cables. The shuttle car had a servomechanism-guided cable drum which would wind and lay out its cable unattended. The cables for the miner and front loader had to be brought forward manually, an operation requiring an estimated 5% of the total man-hours.

Operation of the miner requires 183 m^3 of air pressurized to around 8 atm (120 psi). The air is needed to remove the pilot bore cuttings and to cool the anchoring packers to ensure a firm hold. Ventilation to supply fresh air and remove heat generated by the machines was also needed for efficient operation.

The last step in the whole operation was dump handling. Normally there are three possible methods for dumping waste materials in a tunneling operation: dumping downhill with an ever-extending ramp, either parallel or perpendicular to the slope; conveying uphill (in this case the operation becomes a stage of haulage such as open pit mining); and handling the muck on grade level. The topographical situation at the tunnel site called for handling on grade. Several methods were tried:

1. Dumping individual shuttle car loads over a field about 70 × 140 m (200 × 400 ft) and spreading by bulldozer at the end of two shifts. This method was satisfactory since the following summer melting removed most of the material.

2. The gradual buildup of a 22° ramp by end-dumping from the shuttle car. Allowing the ramp to grow to a height of 1.5 m resulted in haulage delays. Such a ramp had to be removed with a bulldozer.

Function and performance

Framework of development. The framework of the present research was the search for and evaluation of rapid methods of permafrost excavation for military purposes. A new method incorporating the revolutionary pilot pull principle was selected and great attention was given to its performance and potential. Observations confirmed that pulling the machine into the face instead of relying on weight or having hydraulic rams working against tunnel walls results in a general lightening of construction, increased mobility and high performance rates.

It is emphasized that the test vehicle was a first generation machine with many mechanical deficiencies. The overall performance was found to be affected by both the machine's functions and deficiencies and the new environment - warm permafrost - in which it was working. The properties of the permafrost (warm, fine-grained, supersaturated) together with a tooth design and cutting speeds unsuitable for the material led to a situation where the pilot pull principle of face-crowd could not be shown to its full advantage.

With a continuously operating machine in combination with an adequate waste disposal system, the costs of a tunneling operation similar to the present one might very well be below those of any conventional mining system. It must be remarked, however, that cost in a military operation often becomes subordinate to mobility, speed, simplicity of operation, and relatively low weight.

Response of machine to environment. The pilot boreholes cut into the face at the beginning of each cycle are only 1 cm larger than the packers before expansion. Axial pressure on the packer rings expands them toward the walls of the hole providing anchorage. Since the fine-grained ice-saturated silt has a high temperature, very close to zero C, heat leaking along the pilot tubes was found to be warming it to a degree where rapid creep occurred.

Refrigerated compressed air was blown continuously through the packers but the benefit was only moderate and diminished as tunneling progressed. Once the anchors failed, it required 2 to 3 hours to cool the soil to a temperature at which it was capable of holding the packers in place.

The heat generated by the machine and rejected into the tunnel resulted in an additional ventilation requirement. A 12-in. collapsible hose was installed and outside air was blown into the tunnel. The hose terminated against an automotive radiator installed in the antifreeze circulation system of the Alkirk miner. However, the air traveling through the hose gained up to 3C, depending upon tunnel length. An increase in efficiency was noted with the installation of a 6-in. rigid suction pipe to remove air from the vicinity of the machine.

In general, ventilation demand in permafrost tunneling exceeds that otherwise needed, for its main purpose is removal of reject heat. Heat removal from a working machine by ventilation may be considered inefficient but no other methods are as convenient.

Table IV gives a rough estimate of ventilation needs at two different tunneling rates, made on the basis of power consumption.

Table IV. Ventilation demands for the Alkirk excavation system as related to ambient temperature and tunnel cutting rates.

	Ventilation demand	
Outside air temp	*Cutting rate (1 m/hr)*	*Cutting rate (2 m/hr)*
-10C	425 m³/min	900 m³/min
-15	275	550
-20	186	350
-25	155	275
-30	120	270
-35	100	200
-40	80	175
-45	60	150
-50	40	120

Table IV is not based on field data but on a simplified assumption that the machine rejected all its heat into the surrounding air which had to be removed at ever-increasing rates as the ambient temperature rose. Unfortunately, the experimental work did not afford either sustained cutting at either of the two rates or ventilation sufficient to remove the heat generated.

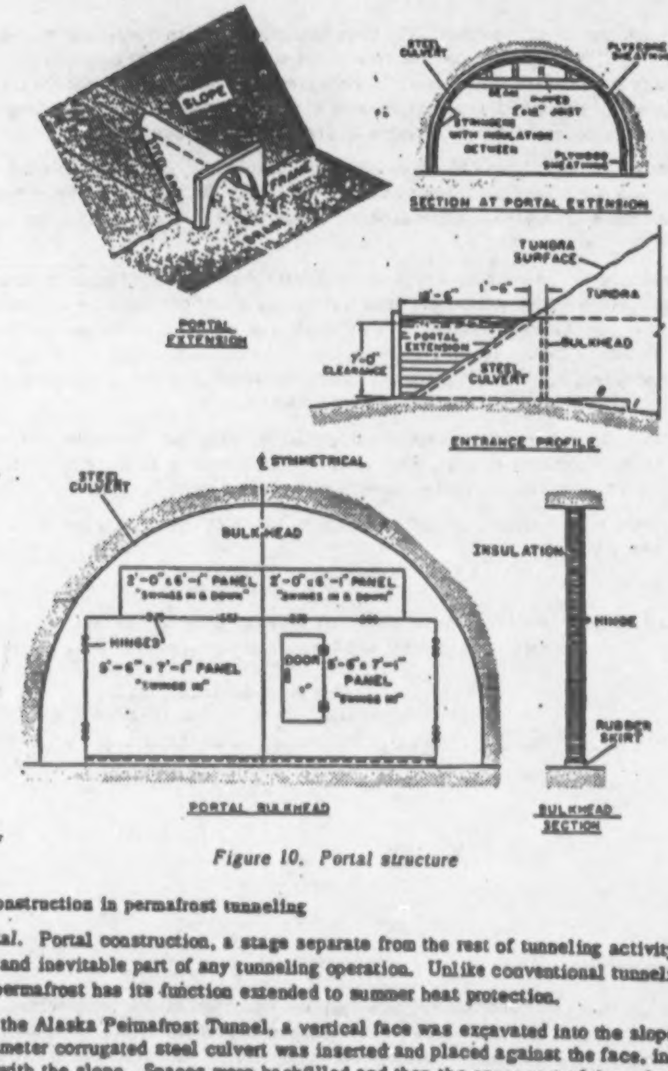

SLOPE
FRAME
PORTAL EXTENSION
STEEL CULVERT
PLYWOOD SHEATHING
BEAM
2"x12" JOIST
STRINGERS WITH INSULATION BETWEEN
PLYWOOD SHEATHING
SECTION AT PORTAL EXTENSION
TUNDRA SURFACE
TUNDRA
1'-6"
7'-0" CLEARANCE
PORTAL EXTENSION
BULKHEAD
STEEL CULVERT
ENTRANCE PROFILE
℄ SYMMETRICAL
STEEL CULVERT
BULKHEAD
3'-0" x 6'-1" PANEL "SWINGS IN & DOWN"
3'-0" x 6'-1" PANEL "SWINGS IN & DOWN"
HINGES
5'-6" x 7'-1" PANEL "SWINGS IN"
DOOR
5'-6" x 7'-1" PANEL "SWINGS IN"
PORTAL BULKHEAD
INSULATION
HINGE
RUBBER SKIRT
BULKHEAD SECTION

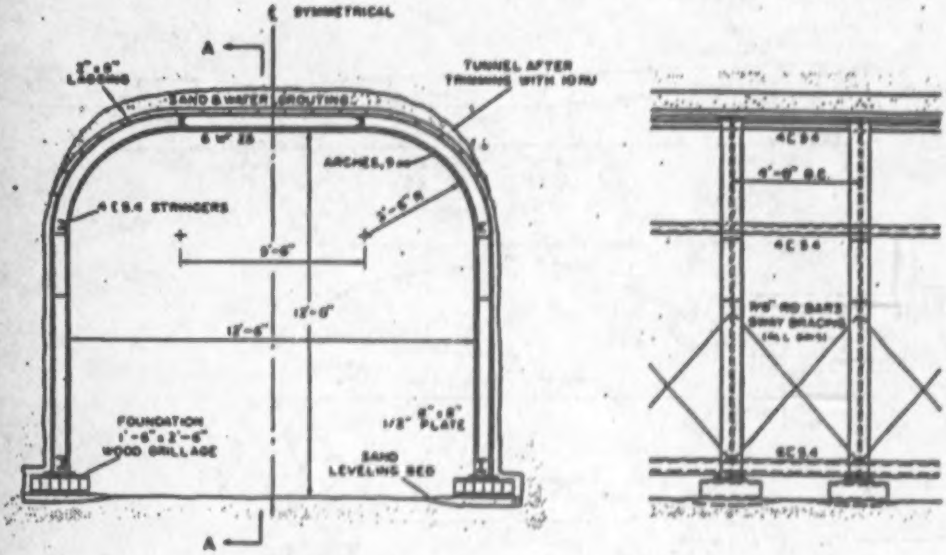
Figure 10. Portal structure

Special construction in permafrost tunneling

Portal. Portal construction, a stage separate from the rest of tunneling activity, is an important and inevitable part of any tunneling operation. Unlike conventional tunneling, a tunnel portal in permafrost has its function extended to summer heat protection.

For the Alaska Permafrost Tunnel, a vertical face was excavated into the slope and 5.4-m (18-ft) diameter corrugated steel culvert was inserted and placed against the face, insulated, and cut flush with the slope. Spaces were backfilled and then the cover part of the culvert was backfilled with gravel. The slope immediately above the culvert was protected by radial brine pipes for artificial freezing in case of a catastrophic thaw.

The steel culvert was extended by a semicircular wooden structure to deflect rain and any material sliding down the unstable slope. Inside the portal structure was an insulated wooden bulkhead with composite doors. Figure 10 shows the portal structure as it was built.


SYMMETRICAL
A
2" x 8" LAGGING
TUNNEL AFTER TRIMMING WITH 10RU
SAND & WATER GROUTING
6 W 25
ARCHES, 9
4 [5.4 STRINGERS
5'-6" R
9'-6"
13'-0"
17'-6"
FOUNDATION 1'-6" x 2'-6" WOOD GRILLAGE
6" x 6" 1/2" PLATE
SAND LEVELING BED
A
4 [5.4
4'-0" O.C.
4 [5.4
1/2" RD BARS SWAY BRACING (ALL BAYS)
4 [5.4

CROSS SECTION

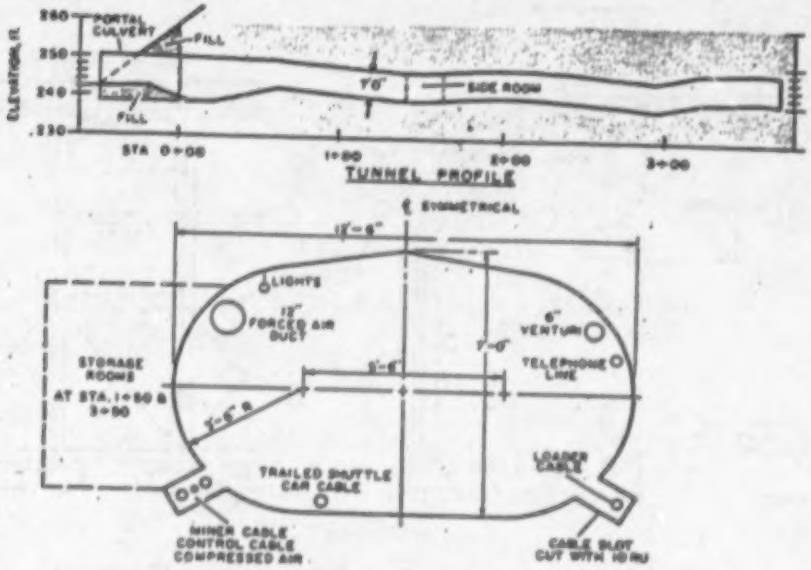
SECTION A–A

Figure 11. Arch roof supports.

Arches. To make the permafrost tunnel safer, nine welded steel arches of 6WF25 sections were installed in the first 8.6 m of the tunnel (*Fig.* 11). The arches were designed to yield rather than rupture should a full overburden load suddenly develop, and were intended to protect against roof settlement. The measure was an added safety feature for the specific case, since the tunnel was to be driven into an unstable man-made slope in an area where earthquakes are common. Standard yieldable mining arches were not used as the profile of the tunnel was incompatible. The narrow space between arches and permafrost was lagged with 2 x 8 timber and grouted with moist sand.

Tunnel configuration. Normally, a tunnel driven into a warm rock under conventional conditions is likely to be subject to water seepage or flood. For that and other purely mining engineering reasons, it is customary to design and to drive a tunnel at an upward gradient of a few degrees.

From the beginning of the operation, partially due to difficulties with horizontal and vertical alignment, the Alaska Tunnel was driven in defiance of that rule (see *Fig.* 12). Its shape differed from that of conventional tunnels in that it had a depression of the floor at the portal to accumulate cold air. It was hoped that this would result in colder permafrost near the portal which might have been beneficial since the oval section of the tunnel had to accommodate movement of men and machines. For convenience and safety the power cables, air hoses, and telephone lines were placed in slots cut longitudinally into the lower part of the tunnel. As an additional safety measure, a heat exchanger was placed in the tunnel at the highest point in the portal area. It was connected with a compressor installation to be used if the portal area became dangerously warm.


260
PORTAL CULVERT
FILL
250
240
FILL
230
ELEVATION, ft
7'0"
SIDE ROOM
STA 0+00
1+00
2+00
3+00
℄ SYMMETRICAL
13'-6"
LIGHTS
12" FORCED AIR DUCT
6" VENTURI
7'-0"
TELEPHONE LINE
5'-6"
STORAGE ROOMS AT STA. 1+50 & 3+50
7'-6" R
TRAILED SHUTTLE CAR CABLE
LOADER CABLE
MINER CABLE
CONTROL CABLE
COMPRESSED AIR
CABLE SLOT CUT WITH 10 RU

TUNNEL PROFILE

TYPICAL TUNNEL CROSS SECTION

Figure 12. Profile and cross section of the Alaska tunnel.

PERFORMANCE OF THE MINER

Excavation by a continuous mechanical method

Potential performance of the machine. Observations on the operation of the machine led to the general conclusion that the Alkirk Continuous Miner is potentially capable of sustaining an excavation rate of several meters per hour. Remedy of certain structural and mechanical deficiencies (to be discussed later), the provision of heat removal, and an adequate supply of power and refrigerated compressed air are all prerequisites.

An adequate continuous haulage capacity is very important since without simultaneous debris removal the machine buries itself in its muck pile in a matter of minutes.

Observations on cutting strain and power consumption. One problem needing a special approach was observation of the dynamic cutting forces as related to power consumption, face pressure, pressures of hydraulic fluids, etc. This was done by means of strain gauges, pressure transducers and recording wattmeters in a system designed by C.A. Brewer (1965). The cutting force transducers consisted of a standard Alkirk tool holder, undercut at the proper place, and two strain gauge rosettes applied in a way that eliminated the possibility of mechanical damage and influence of thermal shock. The calibration was by application of known loads in the usual manner (Fig. 13).

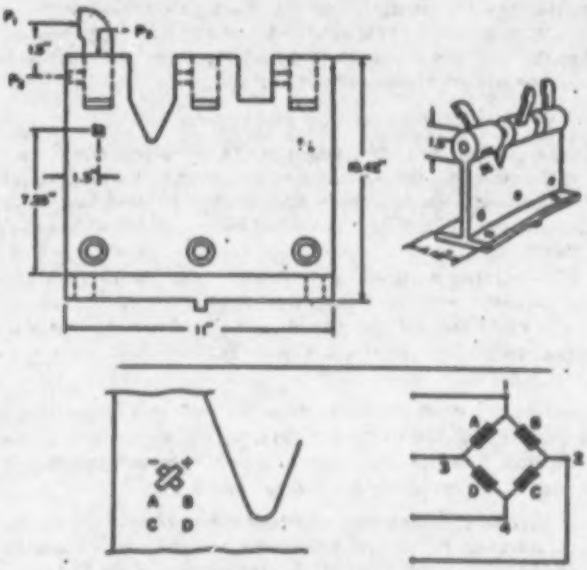


Figure 13. Cutting force transducer arrangement.

Since the Alkirk cutting tool revolves around a shaft the data from the load cells were transmitted by radio into the tunnel where they were recorded simultaneously with all other information.

The machine's hydraulic system was monitored by two GEC fast response resistance type pressure cells at the face pressure and packer pressure lines. Finally, power consumption was recorded at all stages of the investigation. The measurements were made by G.A. Brewer (1965) under contract with USA CRREL. He reports an average of 64 kw power consumption during cutting and 32 kw idling, packer pressure 1400 psi, face pressure (crowd) 500 psi, and a cutting force between 500 and 1100 lb.

During the miner operation, sharp peaks of face and packer pressure that could have been detrimental to the hydraulic system of the machine were recorded. Brewer expressed concern that high pressure surges are most probably the cause of numerous hydraulic leaks, O ring failures and line bursts.

Labor requirements. The personnel occupied with experimental tunneling consisted of two engineers, six technical personnel and the project leader. Normal production tunneling in a similar environment would require one mechanic, specially trained to operate the miner; one helper, doubling for outside work, such as compressor-plant help; one shuttle-car operator; one front-loader operator; and one general helper. An additional man would be needed to take care of outside work.

It is important to mention that trials showed that increasing manpower did not increase productivity. An extra mechanic on the crew did help during repair of the miner. Employment of more than two repair men is not beneficial owing to crowded conditions at the tunnel face.

Much depends on the crew's training. In addition to being a certified mechanic, the miner operator must have at least three months of specialized training. His helper must be a mechanic, who could be trained on the job. The shuttle-car and front-loader operators may be heavy-equipment operators who could be trained in the course of one day.

An experienced miner should operate the muck pile outside.

Other observations on the machine. Operation manuals, manufacturer's instructions and blueprints of the Alkirk Continuous Miner indicate a very complex hydraulic system which in the prototype machine under test was prone to frequent failure. Most frequent were air locks in valves, broken lines and fittings, failures in hydraulic pumps and motors, and fluid leaks in pilot tubes. Maintenance records for 30 shifts (about 22 hours actual mining) show 98 gallons of hydraulic fluid was lost. Specialized testing equipment and special training for the mechanics would have lessened lost time. Another deficiency of the hydraulic system, insufficient cooling of the fluid, resulted in overheating of pilots and soil, and slip of anchor packers. It seems plausible that the frequent line bursts and other failures were due to the extremely high peaks in hydraulic fluid pressure as observed and reported by Brewer (1965).

The failure of packers to provide support for crowd pressure was responsible for a large percentage of the mining time loss. As mentioned, the cause was cumulative: packer design insufficient for local permafrost, need for excessive crowding (see below), insufficient heat removal capacity, and frequent idling due to insufficient hauling capacity.

Two other construction deficiencies were a frequent source of delay during the main tunneling procedure. One was the tracks of the machine which were inadequate for walking on ordinary surfaces. The machine had to be moved on plywood to prevent tearing the tracks. In several instances tracks were damaged when a small foreign body such as a pebble became jammed between cleats.

Serious deficiencies were found in the alignment system. For correctional horizontal alignment, the design procedure requires application of additional face pressure on the cutter opposite the direction in which it is desired to turn. Besides being ineffective, this is detrimental to the pilot tubes and their oil seals. It was found that the only opportunity to change horizontal direction came at the end of the cycle. The pilot tubes were extracted, the machine was backed away from the face and realigned in a new direction, and new pilot holes were cut. At times it was necessary to plug and refreeze the old pilot holes. This technique permitted a correction of a few degrees at a time.

Vertical alignment presented more serious problems owing to the mechanism provided for it. The machine had a tilting device to raise or lower the cutting parts simultaneously. Figure 14a,b shows the alignment for horizontal cutting and a configuration for raising the centerline of the tunnel. The angle is exaggerated for clarity. Note that the dimension of the tunnel (a) is identical with that of the new tunnel, while tilting the overall size of the cut (b).

Attempts to raise the tunnel by the existing method resulted in binding the machine at the face, bending of pilot tubes and failures of the upper cusp cutter.

It appears that an arrangement similar to that used in snow millers (the Peter Snowmiller for example) would solve the problem. Figure 14c represents a proposed configuration for straight line cutting and Figure 14d shows the cutting mechanism lifted *parallel* to the axis of the tunnel. Figure 14e shows the configuration for directing the tunnel dowward.

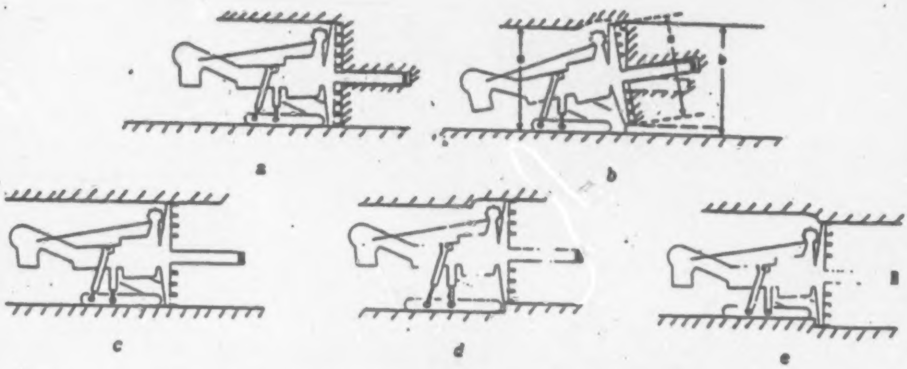


Figure 14. Existing and suggested vertical alignment principles.
a,b: Existing method, distances a and b unidentical.
c,d,e: Suggested mechanism: No change in tunnel dimensions.

Another solution would be to widen or narrow the tunnel diameter at will by 1 or 2 cm. The effect of such an arrangement would be much the same as that shown in Figure 14, d and e.

Cutting action

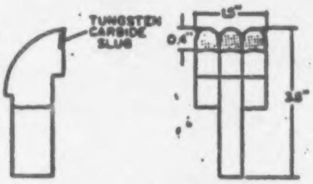
The main job of excavation was done by two circular counter-rotating windmill cutters set in position to cut most of the oval outline of the tunnel. The description that follows concerns the main action of the machine - the two cutting arms in circular motion.

The maximum cutting speed on the periphery of the two cutters is 67m/min (220 ft/min) at 10 rpm; all other parts of the cutters move correspondingly slower. The cutters are armed with standard drag bits (Fig. 15). The teeth on all four arms are positioned so that alternate passes over the face leave a system of grooves and lands (Fig. 16). The 2.4-cm-thick lands broke off from time to time, apparently without a notable expenditure of energy.

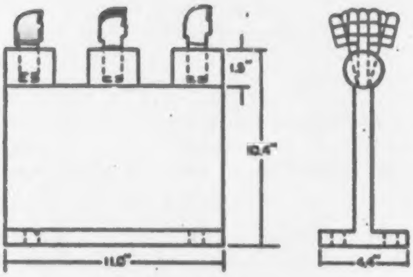
During an early tunneling stage an attempt was made to cut the whole face without leaving any grooves or lands (Fig. 17). This resulted in formation of fine cuttings, slow progress and overload of the machine. It was concluded that tightly spaced drag bits do unnecessary work, using additional energy to disintegrate the material excessively.

The following findings connected with the cutting process are based on direct measurements and experimentation.

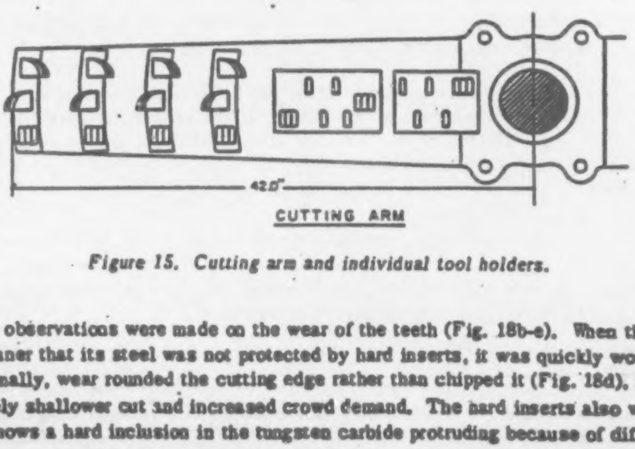
To cut grooves wide enough for the tool holder, a single bit of 5-cm edge width was originally used. The tungsten carbide edge soon began to chip in several places, resulting in an irregular curvature which rendered it useless. But measurement showed that individual chips were about 1 cm away from each other, leading to modification of a standard drag bit (Fig. 18a). The finally chosen position of the drag bits in the individual tool holder is seen in Figure 15.



FABRICATED DRAG BIT



BIT HOLDER ASSEMBLY



CUTTING ARM

Figure 15. Cutting arm and individual tool holders.

Further observations were made on the wear of the teeth (Fig. 18b-e). When the tool moved in such a manner that its steel was not protected by hard inserts, it was quickly worn away (Fig. 18 b,c). Normally, wear rounded the cutting edge rather than chipped it (Fig. 18d), resulting in a progressively shallower cut and increased crowd demand. The hard inserts also wore unevenly. Figure 18e shows a hard inclusion in the tungsten carbide protruding because of differential wear.

The action of drag bits in homogeneous permafrost is shown in Figure 19. In an experimental slow cut a sharp bit was moved across a frozen sample (Fig. 19a). Its initial engagement produced a plastically deformed and compressed area (b), which, when motion was allowed to continue, increased until the first brittle chip failure occurred (c). The compressed area disintegrated immediately thereafter. A dull tool tended to "ride up" on the face, requiring much more crowd force to stay in the face and producing a large amount of smaller, plastically deformed chips

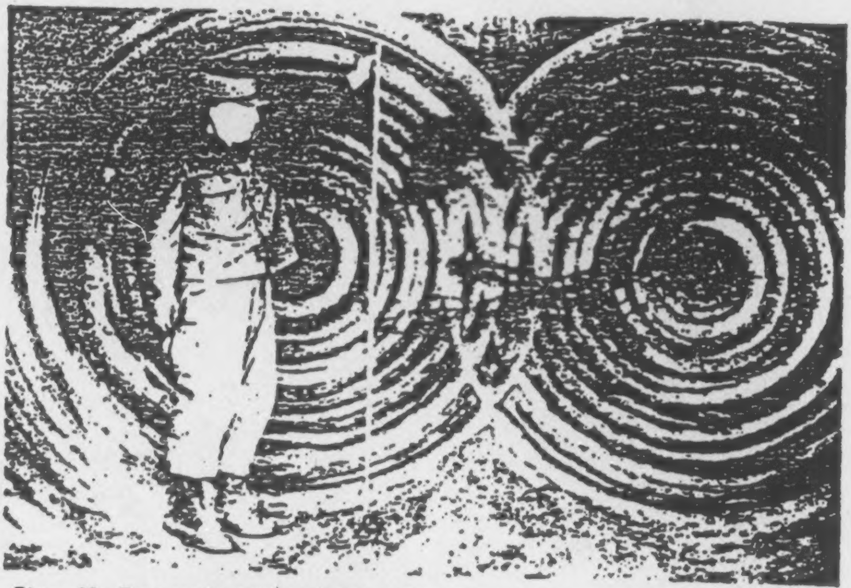


Figure 16. Face configuration consisting of cut grooves and lands. Gravelly part of tunnel.

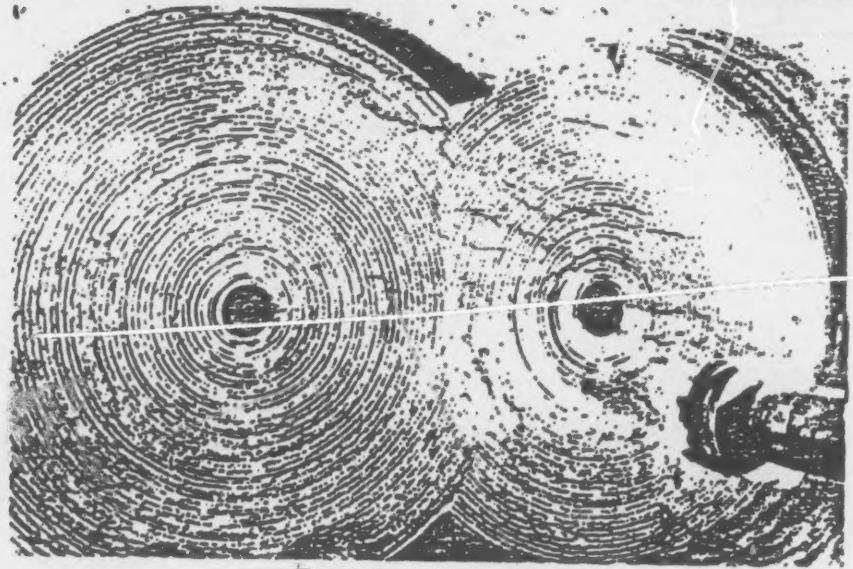


Figure 17. Full face cutting.

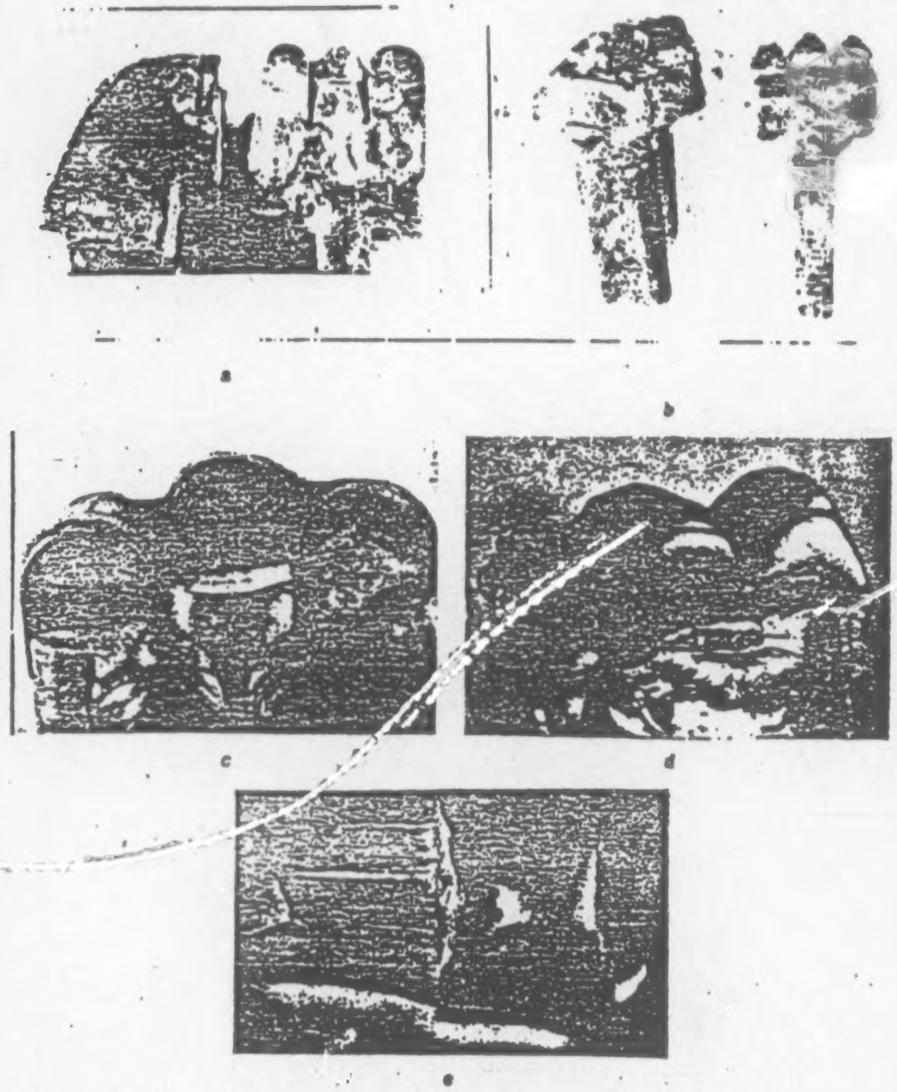


Figure 18. Triple edge drag bits.

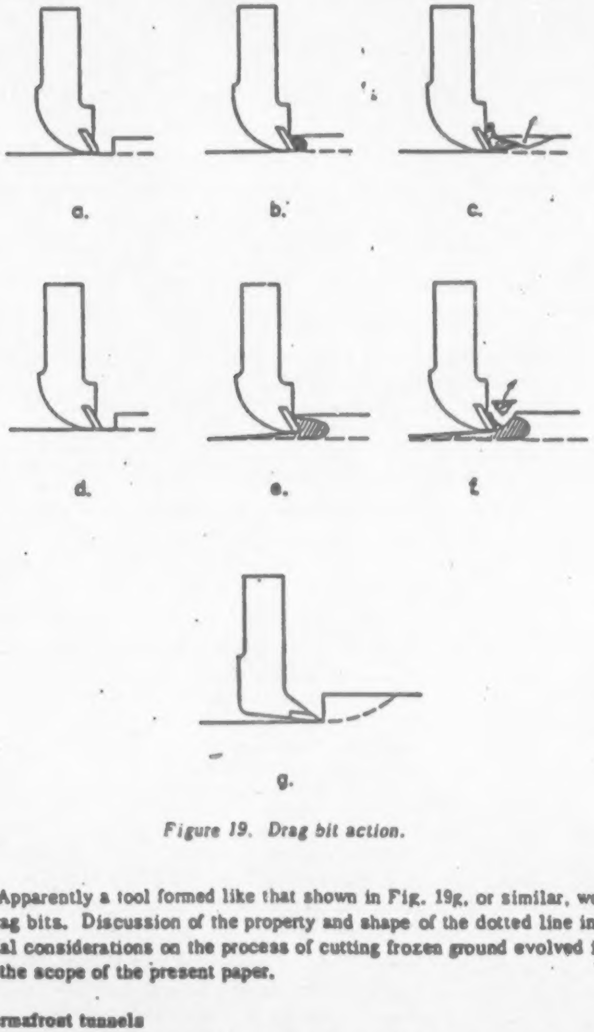


Figure 19. Drag bit action.

(Fig. 19d,e,f). Apparently a tool formed like that shown in Fig. 19g, or similar, would work better than standard drag bits. Discussion of the property and shape of the dotted line in Figure 19g as well as additional considerations on the process of cutting frozen ground evolved into a research program beyond the scope of the present paper.

Properties of permafrost tunnels

Plastic behavior and mode of failure. It is often said that permafrost is a rock material formed from any soil material by frost consolidation of its pore water. From this mining engineer's classification of permafrost, one visualizes a large variety of properties dependent upon temperature and composition. Properties of a large variety of permafrost types are compared on the following pages with similar rocks cemented by means other than freezing pore water.

As a cement, ice is weak and under sustained load is subject to greater plastic deformation than are cementing agents like calcite and dolomite in sandstone and conglomerates. A subsurface excavation in sandstone; siltstone or conglomerate becomes subject to brittle roof failure before any measurable plastic deformation occurs. But pillars in permafrost fail plastically and such a phenomenon as rock burst is unthinkable in permafrost tunnels over the whole range of natural temperatures.

Our own observations of deformation in frozen matter began with ice tunnel deformation in the massive ice of the Greenland Ice Cap (Swinzow, 1962). It was found that clean ice may deform slower than mixtures of frozen rock debris. Further observations indicated some types of permafrost with little or no plastic deformation: In three years a room of 65-ft span, dug in cold, bouldery, unsaturated (approximately 25% moisture) permafrost, did not deform in excess of measurement error. Permafrost of coarse material with dense packing does not readily deform plastically. Conversely, fine grained, supersaturated permafrost especially at high temperatures has a tendency to deform plastically. It appears that the solid soil particles weaken the ice. Observations at the Alaska Experimental Permafrost Tunnel (Fig. 20) showed noticeable deformation with only a small amount of overburden. Since the tunnel was dug under only gently sloping terrain, the perceptible difference in deformation rates could be tentatively explained only by the temperature difference between the middle of the tunnel and a point toward its work face or portal. The permafrost temperature difference between the two points was close to 1C while air temperature differences varied during the observation period, the point at 350 ft always being warmer.

The plastic behavior of local permafrost as well as experiments with explosives indicate that brittle roof failure is improbable under the influence of high velocity shocks such as large explosions at the surface. Although often weaker than materials cemented by other means, permafrost provides a safer roof under certain overburden and span conditions (Livingston, 1960).

Ground temperatures around a large cavity change with time. If the opening of the cavity is higher than its main space, its temperature will decrease and be lower than the annual average. Conversely, caves with a main room above the entrance are warmer than the mean annual temperature. In the first case, the cold winter air settles down in the cave and is not readily removed during the summer. As soon as the outside temperature becomes lower than that of the cave, air exchange begins. This is how so-called ice caves form in moderate climates. This effect, useful as it is, is not being utilized sufficiently at the present time.

A nearly horizontal opening in permafrost is subject to air currents that reverse their direction with the change of seasons. Anemometer observations in the Alaska Tunnel indicated that in the winter the relatively warm air moved along the roof toward the portal with maximum velocities reaching 2.5 km/hr and was replaced by cold air moving in along the floor. The simple measure of closing the portal tightly and reducing the inside activity to a minimum in the summer was sufficient to accumulate some heat sink capacity.

Artificial ventilation was inadequate since the air forced through the pipes arrived at the end of the tunnel several degrees warmer than the outside temperature. After the final excavation season a vertical shaft was drilled at the end of the tunnel. During the cold winter months it provided a strong chimney effect with rapid air exchange and effective cooling. The air circulation in the closed tunnel is limited to vertical convection between floor and roof.

Sublimation. Stable ice can exist in contact with air only if the air is saturated in respect to ice molecules. In cases of dry air (low relative humidity), ice "dries out." Sublimation is well understood and studied; its rates depend upon interface shape and ice vapor pressure (and therefore temperature). If at a given temperature and low air humidity, sublimation produces an increased amount of vapor in the vicinity of the interface, free air movement adjacent to it removes

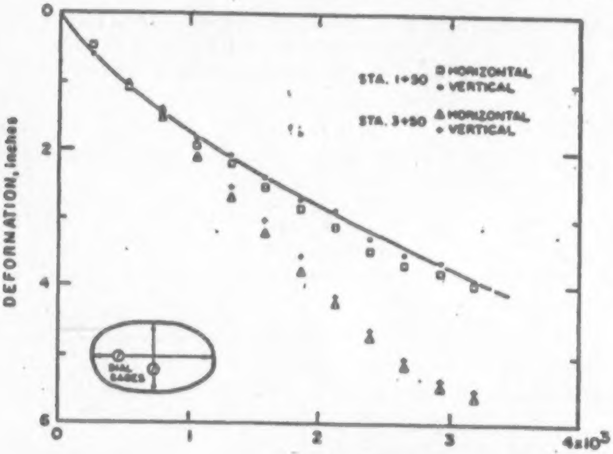


Figure 20. Relation of time to deformation at sta. 1+50 and 3+50.

the vapor concentration gradient, thus keeping the process of sublimation at a constant, rather than a decreasing, rate.

Permafrost surfaces, consisting of many solid particles of soil alternating with ice, are also subject to sublimation. In the tunnel a smooth, firm, freshly cut surface became dusty after a short time. The thickness of the dry layer increased rapidly, reaching 1 to 1.5 cm in a week. The layer was firm but very friable and strong air currents disturbed it and made the tunnel air dusty.

The rates observed in the field, as well as those reproduced in laboratory studies (Luyet, 1967), could not be made to correspond to any rigorous prediction. In the field, temperatures, air humidities and ventilation rates changed almost hourly. Since one purpose of the laboratory work was to set up a standard condition close to the average natural one, tests were conducted at -2C and 50% relative humidity. The tests revealed that the permeability for water vapor was constant and that sublimation occurred at decreasing rates. The increased thickness of the dry shell was apparently the main factor bringing the process to a halt. Observations in the tunnel indicated that an undisturbed dry dust shell may reach 14 cm in about 65 days, by which time the process is slowed down to an imperceptible rate.

Earlier work on prevention of sublimation from frozen ground surfaces revealed that simple measures such as spray painting, lacquering or coating with a non-drying petroleum product were sufficient to arrest the process fully over a period of five years (Swinzow, 1964).

Causally unrelated but intricately connected with sublimation is the process of hoarfrost formation in a closed permafrost tunnel with very little outside air entering and only limited human activity underground.

The Tuto, Greenland, permafrost tunnel is an example. The lower part of the tunnel is drying out by sublimation while hoarfrost grows in thick layers of crystals all over the upper part. The tunnel is dug on a gentle rise and the sharp demarcation line between drying and deposition is horizontal. In the portal area it is about 0.75 m above the floor and merges with the floor at 164 m. The continuously growing masses of hoarfrost crystals on the roof fail under their own weight and land on the floor where they are subject to sublimation. This circulation of moisture is another check of sublimative drying of permafrost below the horizontal dividing line. Observations using ammonia fumes as markers revealed convection of air between roof and floor, the upward stream being in the middle of the tunnel. Apparently, it is a double convection cell with a maximum flow velocity of 0.7 m/min.

Similar phenomena will probably be observed in the Alaska tunnel when active research ceases and forced ventilation is discontinued.

SUMMARY

Military uses of an excavation in permafrost

Previous investigation has indicated that frozen ground responds poorly to disintegration by all types of explosive application. In subsurface exploration it is the poor powder ratio; in surface blasting it is the low yield and only moderate effect of bombing and artillery (Livingston and Waldron, 1965).

Most important, however, is the specific response of roofs in subsurface excavations to blasts set off at the surface. The danger of brittle roof failure is, in the writer's opinion, minimal since brittle response of permafrost during short duration loading occurs only over a limited range of stress. Unless a shelter in permafrost is very shallow, so that overburden thickness is close to span width, brittle roof failure is unlikely as long as the roof contour is outside the direct fracture zone of the explosion.

Observations in Greenland conducted on cold, bouldery permafrost with a span of 20 m demonstrated a lack of response to explosive shocks from the surface as well as free blasts inside the tunnel.

The flexibility with which the frozen state may be put to use in excavations is also attractive for military purposes. Using a type of "concreting masonry" work, repairs of all sorts may be successfully performed in permafrost tunnels (Swinzow, 1964). Should roof crevices form in the process of excavation, they are easily repaired by use of a sand-water grout, which freezes back, rendering the needed strength and safety. Where plastic deformations are taking place, such as the present tunnel, they either could be accounted for in advance, or arrested by artificial means (such as chilling by winter ventilation).

Ease of excavation is another attraction for military use of tunnels in permafrost.

It has been demonstrated that a comfortable personnel shelter can be constructed in a cave dug in a frozen material. Russell (1966) described in detail an experiment where an insulated camp with all facilities was constructed in an ice tunnel in the Greenland Ice Cap. With sufficient insulation, room temperatures inside the shelter structure can be kept well above those outside. With sufficient ventilation the maintenance of low temperatures in the tunnel outside the building is not a serious problem. The construction of large command posts, bulk fuel storage caves, and warehouse facilities in permafrost appears to be feasible and should be investigated.

Tunneling method

The most striking feature of the Alkirk Miner is the novel pilot pull principle with its advantage of less weight and incipient increased maneuverability. The machine also has relatively low power consumption compared with other continuous mining systems. The rates of cutting obtained were promising. To be practicable, the principle must be applied with compatible, reliable equipment. Modifications of the machine for use in permafrost should include redesign of the hydraulic system, vertical and horizontal control and tramming method, an improvement in anchoring and a heat exchanger.

Cutting speeds are insufficient for the perennially frozen silt. The design of the drag bits also requires consideration although the same bits used on a faster cutting machine performed better regardless of advanced wear (see Fig. 21). It appears that the design of special bits (perhaps such as suggested in Fig. 19g) requires consideration of varying cutting speeds of the machine. The application of the pilot pull principle is highly recommended for possible future excavations in perennially frozen silt deposits.

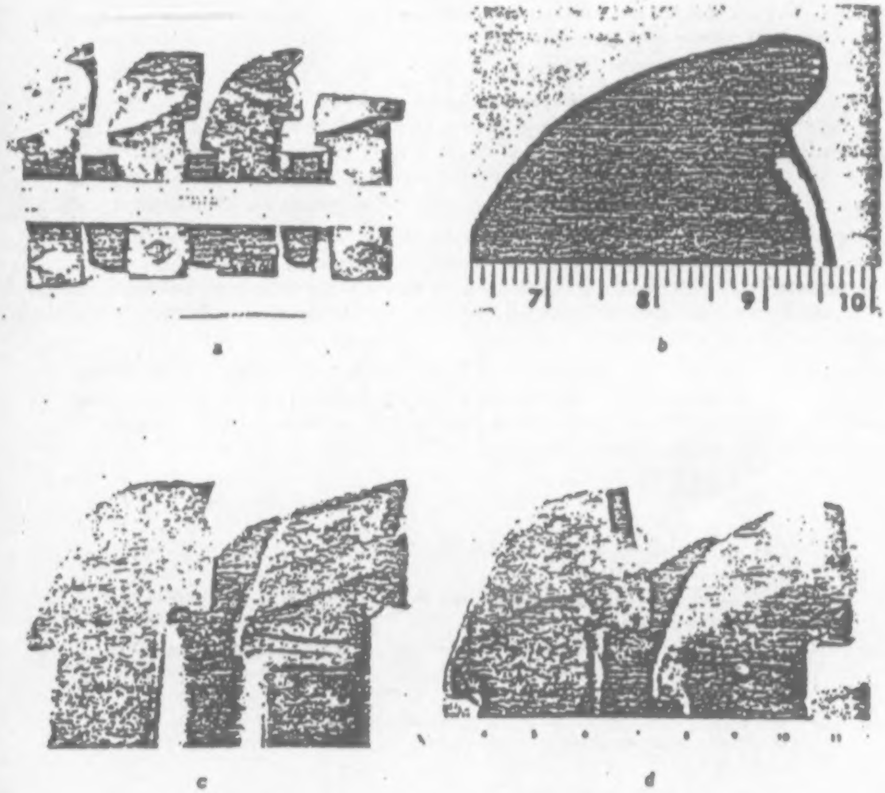


Figure 21. Chain saw teeth of the 10 RU miner.

Some reservations

The Alkirk Continuous Cycle Miner is a "first generation" machine originally developed for excavation in coal and soft rock. Its applicability to warm permafrost was the main purpose of the present application. For this reason, technicalities of construction have been kept to the minimum necessary to explain the principle, its advantages, and its weaknesses. The performance of the standard coal mining equipment used in the project may be stated as satisfactory, its detailed description is beyond the scope and need of the present study.

The overall conclusions were reached under the handicap of incompatibility of standard mining equipment with the Alkirk Miner. For example, the shuttle car used for debris removal (Fig. 9) was incompatible with the machine in two ways: it did not fit under the conveyor and its capacity to remove cut material was far less than the miner's ability to excavate, that is, to produce spoil. The mechanism employed between the two machines - the front loader - corrected only one deficiency, the dimensional incompatibility.

The Alkirk Miner had a low cutting speed and was armed with improper cutting tools. This necessitated excessive crowding which caused frequent anchoring failure. The need for refrigerated compressed air, frequent overloads, and failures in the hydraulic system were doubtlessly connected in part with the above conditions. It is concluded that in order to use the machine to full advantage it should be thoroughly redesigned to a second or perhaps a third generation model.

Despite all reservations concerning performance during the tunneling experiment, it is recognized that the machine has a series of progressive features, its relatively light weight and low power requirement being not the only ones. The pull-in principle is revolutionary and is potentially advantageous. This is connected with possibilities of better maneuverability. Hydraulic drive will potentially provide infinite control.

It cannot be overemphasized that to make the machine work in permafrost, a large research and development effort would need to concentrate on steering methods (Fig. 14c,d,e), anchoring the pilots, improving heat removal, and toughening the hydraulic system. Increasing angular cutting velocity and, especially, designing cutting teeth adapted for the various linear cutting velocities appear to be important.

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APPENDIX A

OBSERVATIONS ON A 10 RU COAL MINER

In addition to the investigation of the Continuous Cyclic Mining System described in the text, a standard 10 RU Mining Machine was subjected to a brief test. The machine is normally used in long-wall coal undercutting and in other specialized underground work.

The Joy 10 RU Cutter is a self-propelled, cable laying, tire-based machine working on a chain saw principle. It is powered by two motors: a 30-hp motor driving the hydraulic system and a 50-hp motor driving the chain saw. Both are 440-v ac.

The machine has a variable tram speed, the maximum being 70 m/min. Its cutting speed of 183 m/min was successful, in the way permafrost disintegrated.

One advantage was the extreme simplicity of operation — the 10 RU could be operated successfully after only a few hours of training.

The versatility of the machine permitted its use for a variety of functions such as trimming the tunnel profile to a desired shape, cutting notches in the wall of the tunnel for cable and pressure hoses, and excavating large rooms with flat walls.

Although the purpose of the machine is not tunneling, an attempt to do so was successful. The machine was used in a discontinuous cycle, e.g. about 2-m-deep cuts were made at first vertically along the edges of the face and then horizontal cuts were made every 20 cm beginning at the bottom. In this way, the face advanced 2 m per cycle after the front loader and shuttle car removed the debris.

The chain of the machine was armed with drag bits essentially of the same size and configuration as those in the Alkirk Miner. Apparently due to the high cutting velocity, the 10 RU produced debris that was more uniform and of coarser size than that produced by the Alkirk Miner. While particles liberated by the teeth of the Alkirk Miner were between 2 mm and 1 cm, and the whole muck pile contained a large amount of dust, the cuttings produced by the 10 RU were from 3 to 7 cm in size with a very small amount of dust, indicating a more efficient operation.

Correspondingly, the expansion factor in the muck pile of the 10 RU Miner was found to be low (1.8) compared with that of the Alkirk Miner (2.45).

Observations on the wear of cutting teeth together with the material removed indicate that the Alkirk machine "cuts" by slow induced failure; the faster 10 RU cutting speeds ensure brittle failure with all its advantages. Furthermore, since the expansion factor could be kept smaller with the 10 RU, its cutting process seems to be more advantageous. (It is emphasized that a lower total specific surface of the cut material is always advantageous.) Since the latter parameter is in direct relation to expansion factor, special observations were not needed.

Also of interest is the low dependency of the machine's performance upon the condition of its teeth. While the progressive wear of teeth on the Alkirk machine during the slow cutting was accompanied by increasing crowd demand and higher packer pressure with all its consequences, partial or full loss of cutting edge of the teeth of the 10 RU produced virtually no adverse effect on performance.

Figure 21a shows the normal sequence of tooth wear in the Fairbanks silt. The last tooth performed as well as the others did. Figure 21b shows an enlargement of the third from left tooth indicating its mode of disintegration.

In some cases, defective manufacturing resulted in absence of clearance (Fig. 21c) but subsequent wear corrected the situation.

Sometimes improper insertion of tips resulted in poor performance (Fig. 21d). For example, one tooth with a poorly set edge, all others being proper, generated enough vibration to disengage the saw from permafrost.

PRODUCTIVITY OF OPERATION

Since the construction of the tunnel was not the sole purpose of the research (neither was a test of the machine *per se*), a precise prediction of its efficiency is impossible.

The tunneling equipment had to be engaged in tandem (see Fig. 9). The Alkirk Miner, on the extreme right, combined two functions, cutting the face and elevating the cut material with its conveyor. Since the shuttle car would not fit under the Alkirk Elevating Conveyor, the Joy Front Loader had to be switched in between. Finally, the dump conveyor-equipped shuttle car picked up the material and transported it to the muck pile.

The equipment was supplied with power as shown in the left diagram of Figure 9. The right diagram shows the routing of compressed air to the miner and venturi pump (not shown) used to evacuate warm air from the machine. In addition, there was a string of lights and a field telephone close to the face connected with the powerhouse and outside.

This set-up was partially described in the main text. Accurate prediction of production performance is difficult but during the report period the machine produced 63 m of tunnel in 21 hours of operation.

The performance of the equipment was observed and data collected in order to detect possible weaknesses. All malfunctions and breakdowns were noted and categorized (Table AI). An indicator of the extent of failures is the down-time during repairs.

Rebuilding and redesigning certain components of the machine would undoubtedly improve the function of others. For example, a better design would eliminate packer slip; elimination of hydraulic hammer effects would result in elimination of many component failures.

All mining was accomplished within 30 9-hr shifts. Since six production personnel were employed on the average, a total of 1620 man-hours was to account for productivity determination. Besides the 910 man-hours spent on repair of mining equipment and 208 man-hours on mining, a total of 50 man-hours were spent on maintenance.

Table AII gives a breakdown of manpower utilization. Note that the total number of work hours (time) is larger than time available, since most of the activity in maintenance proceeded simultaneously.

Table AI. Mining equipment failures registered during the tunneling operation (from shift reports)

Failure	*Repair time (hr)*
Alkirk Miner	
Upper cusp cutter:	
Axis shorn off	62
Torn drive chain	11
Shorn off support	9
	82
Hydraulic system:	
Line leaks and broken lines	32
Broken pumps and motors	47
Valve failures and air locks	27
	106
Mechanical failures in mechanisms:	
Torn thrust rings	9
Bends in pilot tubes	5
Broken packers	6
Torn tracks	8
Torn bit holders	12
	40
Elevating conveyor:	
Motor replacement	7
Realignment, tooth replacement, Rubber skirt replacement	2
	9
Miscellaneous:	
Front scraper blades bent	5
Operational failures without breakdown:	
Packer slipping	38
Cleaning plugged pilot tubes	3
Realignment of miner	30
	71
Shuttle Car	
Cable torn out	9
Cable insulation embrittled by frost	2
	11
Front Loader	
Frozen lines	2
Frozen conveyor	10
Broken gathering arm bearings	10
Hydraulic line failure	5
	27

APPENDIX A

Table AI (cont'd)

Failure	*Repair time (hr)*
Stationary Equipment	
Malfunctions in refrigerator	10
Power failures	3
	13
Total repair time:	364
Repair in man-hours	910

Table AII. Manpower utilization during 30 9-hr shifts of mining

	Time (hr)	*Labor (man-hr)*
Mining	33.6	307.6
Repairs (Table AI)	364	910
Maintenance		
Miner	143	270
Shuttle car	14	33
Front loader	24	58
Aboveground equipment	19	41
	597.6	1619.6
Available	(270)	(1620)

Besides illustrating the labor utilization pattern, Table AII indicates that a substantial reduction in only two items, repair and maintenance of the Alkirk Continuous Mining Machine, could easily improve its productivity (not mining rate) by at least three times.

The personnel operating the Alkirk Miner did not have any specialized training. It is felt that specially trained people would not be able to increase the productivity of the machine, but would be better than untrained people in making repairs and adjustments.

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JANUARY, 1964

Tunneling in Permafrost, II

by George K. Swinzow

U.S. ARMY MATERIEL COMMAND
COLD REGIONS RESEARCH & ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

PREFACE

This report covers 1960 work as Corps of Engineers Project 39B, Tunneling in Permafrost. The tunnel was begun in 1959 as a project of the Applied Research Branch, with Mr. John F. Abel as project leader, and continued by Dr. G. K. Swinzow for the former Basic Research Branch. The latter part of the work was under the guidance of Mr. James A. Bender, then chief, Basic Research Branch. This report was prepared by Dr. Swinzow.

Field and camp support were provided by the U. S. Army Polar Research and Development Center. SP5 Elmo Bradley, USA PRDC, was shift boss during the 1960 field season.

This report has been reviewed and approved for publication by Headquarters, U. S. Army Materiel Command.

W. L. NUNGESSER
Colonel, CE
Commanding
USA CRREL

Manuscript received 9 June 1961

His findings held true with one exception. A more efficient system of fluid utilization was developed and adopted. Previously, drill water was piped from the surface by gravity flow, and consequently remained in the pipeline for a long time. Therefore, a high percentage of antifreeze was needed to prevent freeze-up. This presented a hazard, since the spent liquid covered the floor without refreezing. In the new method, water was brought into the tunnel in a closed tank, pressurized in place from the air line, and injected into the drills. This required a much weaker solution of antifreeze, as low as 1:25, and resulted in a safe, dry floor.

Drilling time in one cycle averaged from 40 to 60 min. The higher figure resulted when large boulders had to be penetrated. Mucking lasted from 1 to 3 hr, averaging about 7 min a car. A normal 10-hr shift would start with mucking following by drilling then blasting and would be repeated to form two complete cycles. The two ventilating times fell on the lunch hour and shift change. A typical day would result in 8 linear ft of $6\frac{1}{2} \times 7\frac{1}{2}$ ft tunnel — less during crosscutting, room excavation, and other routine jobs. The final average productivity of a double cycle was 5.37 linear ft of tunnel, or 9.7 yd^3 of excavated material.

Personnel and volume of work

Each shift consisted of 1 shift boss, 1 explosives man, 1 drill operator, 2 drillers, and 2 mucker operators.

During each step of the cycle, the men in charge conducted the operation with the remainder of the crew acting as helpers. Using additional men did not increase productivity during regular tunneling. The efficiency of tunneling in permafrost may, however, be slightly increased by using four crews working four 6-hr shifts around the clock. Such an operation may turn out to be more productive and is recommended where speed is more important than cost.

The volume of work amounted to 109 productive shifts with 19 maintenance and construction shifts. Only three shifts were lost because of bad weather. This could have been more had the operation been conducted at the surface. Once begun, tunneling operations in permafrost were not affected by weather conditions.

The total amount of permafrost excavated was 1056 yd^3. Each mining car was filled to an average capacity of 20 ft^3. The excavated material was carried out in 2420 mining car loads which shows that the material expanded 1.7 times. The total drilling footage was 15,245 ft indicating that three average holes were needed to remove 1 yd^3 of permafrost from the face.

Mining equipment

An 18 in. light mining track system was used. This was found to be most satisfactory for a 6.5 x 7.5 ft profile. Under the given conditions, the Type Z (Denver Equipment Company) 24 ft^3 ore car was found suitable. Hand-tramming was employed only for a short time at the start of operations. With longer distances, machine-tramming with a Mancha storage battery locomotive was found to be most efficient. The operation, conducted on a single track, did not require any turnouts or car transfer. Side spurs to various rooms in the tunnel insured mining without an excess of track work. Mucking was conducted with an Limco Model 12b Rocker Shovel. This proved to be a reliable machine, needing a minimum of maintenance. CP-ISL-459 Air Leg Drills (Chicago Pneumatic Tool Company) were used and performed satisfactorily under the specific conditions.

The compressed air supply was affected by the cold environment. Air entering the subsurface pressure lines deposited ice which occupied as much as three-fourths of the pipes' cross section along the entire length of the line. The procedure suggested by Weber (1959) involving an antifreeze spray into the pipeline was impractical, since the diluted solution accumulated in the lower parts of the pipe and refroze. The most economical, although radical, solution was to remove the complete pipe system and melt the ice out, then re-install the pipes. It was found that six men could finish such a job in one shift. Under similar conditions, the de-icing procedure should be repeated every 3 to 4 weeks.

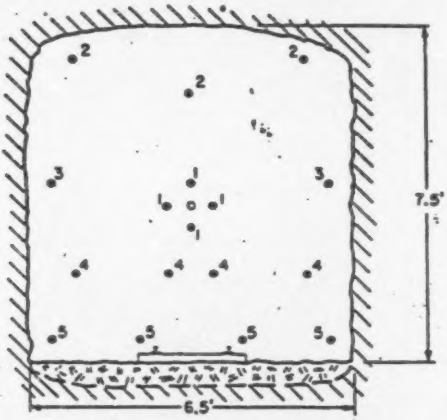


Figure 3. Drill pattern and shot round. Solid circles represent charged holes. Open circle is the uncharged relief hole. Numbers indicate the order of firing.

Complete power needs, including subsurface operations as well as surface maintenance, were satisfied by 35 to 40 kw of a-c current and 300 ft^3/min of air pressurized to 100 psi.

Blasting and explosives

Types of explosives. Nine types of explosives were used in the tunnel during the 1960 season. Normal production would not require such a variety, but it was necessary to find the most suitable explosive for permafrost. Explosives used may be divided roughly into three groups: (a) high strength and velocity; (b) medium strength and velocity, and (c) low strength and velocity.

Group (a) included 100% gelatin (Hercules) and malleable Military Demolition Block C-4 (26,379 ft/sec). Group (b) consisted of a variety of explosives including 65% gelatin (Gelamite 1-X, Hercules), gelatin extra 60%, nitroglycerin 60% (Hercomite), and the Military Explosive M-1. Group (c) was also of great variety including nitroglycerin 50%, gelatin extra 30%, and a 40% gelatin (Dupont). This division was for the experimenter's use and is not meant to be proposed as a standard classification.

Drill pattern. The best drill pattern for advancing in permafrost is a burn cut pattern drilled to two-thirds of the width of the tunnel. The usual fire round shown in Figure 3 is applicable only for normal half-second delay caps. The use of millisecond delays produced irregular fragmentation and the muck was scattered, since the material liberated by the first blast was pushed down the drifts by subsequent explosions while still in the air.

Stemming. Under identical circumstances, stemming becomes a deciding factor in the rational use of explosives. Table Ia shows results for the conventional method of stemming using clay to fill about one-third of the hole. A cold environment such as the Tuto permafrost tunnel (-10 to -13C) presents an excellent opportunity to use another method: mud, wet-tamped, was found to freeze solidly in the drill hole. By experimenting, it was found that a mixture of silt and clay freezes better and locks the hole tighter than conventional clay tamping, which always remains plastic and only serves to plug the drill hole. The favorable powder ratio which was reached near the end of the season is attributed to the refreezing of the stemming. Results for typical cases are given in Table Ib.

Table I. Powder ratio, blasting of permafrost, 1960 field season.

Date	Type of explosive	Amount of explosive in round (lb)	Powder ratio	Pile character	Fragmentation*	General remarks
Conventional stemming						
10 Jun	100% gelatin	70	9.7	Spread	Satisfactory	No stemming used
2 Jun	65% gelatin	60	8.3	Compact	Satisfactory	Regular stemming
3 Jun	65% gelatin	120	8.2	Spread	Poor	No stemming used
16 Jun	65% gelatin	63	8.8	Spread	Very poor	Stemming w/sandy clay
6 Jun	65% gelatin	35	5.6	Extremely compact	Extremely poor	Pile in contact with face
20 Jun	65% gelatin	50	6.9	Compact	Satisfactory	Clay stemming
24 Jun	60% nitroglycerin	126	17.5	Spread	Extremely fine	Poor fumes, decomposed explosive
5 Jun	60% nitroglycerin	139	9.6	Compact	Satisfactory	Unskillful loading, loose tamping
26 Jun	60% nitroglycerin	66	9.2	Compact	Poor	Unskillful loading, loose tamping
b. Frozen stemming						
3 Jul	M-1 med vel	34	4.7	Satisfactory	Poor	Heavy boulders, delayed blast, fumes
15 Jul	100% gelatin	85	5.9	Spread	Fine	Heavy boulders
7 Jul	100% gelatin	67	4.7	Spread	Fine	Heavy boulders
9 Jul	100% gelatin	105	7.3	Satisfactory	Poor/fine	5 cu yd diabase boulder
20 Jul	100% gelatin	42	3.0	Satisfactory	Satisfactory	Tightly stemmed
20 Jul	M-1 med vel	32	4.4	Satisfactory	Satisfactory	Tightly stemmed, some fumes
[illegible] Jul	M-1 med vel	36	3.9	Satisfactory	Satisfactory	Tightly stemmed. Boulders
27 Jul	M-1 med vel	32	3.9	Satisfactory	Satisfactory	Tightly stemmed. Boulders
28 Jul	M-1 med vel	31	3.5	Satisfactory	Satisfactory	Tightly stemmed. Boulders
Aug	M-1 med vel	30	3.3	Satisfactory	Satisfactory	Tightly stemmed. Boulders

Satisfactory: No fragments larger than 1 ft^3.

Poor: Fragments of 1 ft^3 or larger are noticed. Mucking presents difficulties.

Table I. Powder ratio, blasting of permafrost, 1960 field season. (Cont'd)

Date	Type of explosive	Amount of explosive in round (lb)	Powder ratio	Pile character	Fragmentation	General remarks
6 Aug	M-1 med vel	27.5	3.1	Satisfactory	Satisfactory	Tightly stemmed. Boulders.
	M-1 med vel	27.5	3.1	Satisfactory	Poor	Tightly stemmed. Boulders.
10 Aug	40% dynamite	40	3.4	Satisfactory	Medium	Tightly stemmed. Boulders.
17 Aug	40% dynamite	48	3.3	Satisfactory	Medium	Tightly stemmed. Boulders.

Results of observations. The explosives were used under a variety of stemming and priming conditions and different depths of implacement. In addition to the usual safety and stability demands, the nature of the environment imposed the following requirements: (1) medium and low velocities were needed for fragmentation and heave of permafrost, which seemed tough and elastic at the same time; (2) strength was considered of primary importance since the material was of high density and contained large boulders which prevented cratering; (3) insensitivity to frost was required, both in primed and/or residual state, and (4) insensitivity to pressure was required, since stemming and freezing back in the hole could produce considerable pressure on the charge if it contained excess moisture.

It was found that high-velocity explosives were excellent in their shattering action and were ideal for fracturing large single boulders. However, their overall performance was inferior because of their very limited heaving action. Besides this, the Military C-4 became so insensitive that it could only be ignited with very heavy booster charges of nitroglycerin dynamite.

Low-strength, low-velocity explosives required large diameter holes and cartridges or simultaneous detonation, since a normal drill pattern would contain such long charges that they would cut each other off during a sequential blast.

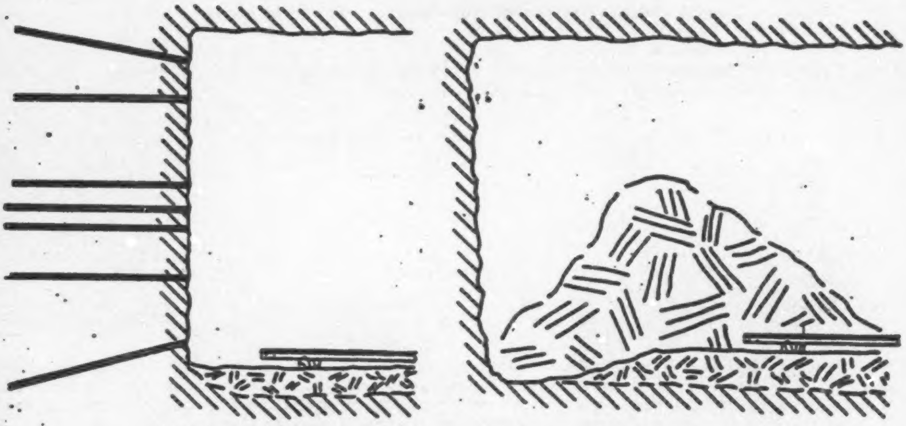
In contrast to Anderson's (1956) recommendations, experiments demonstrated that medium-velocity, medium-strength explosives produced the most satisfactory results.

Table I shows the results of powder ratio investigations for typical cases at various stages of work. Both parts of the table contain experimental rounds of the same drill pattern. Rock conditions and overburden pressure are comparable. The same normal delay pattern was used.

The powder ratio is the ratio of the amount of powder used to the amount of rock disintegrated and is a highly variable factor. It is influenced by the particular set of conditions, such as lithology, type of work, etc. It is also affected by the position of the charge in the hole, manner of priming, stemming, etc. In addition, the low temperature and high apparent elasticity of permafrost, i.e., its resistance to very short duration shock, decrease the efficiency of the explosion. Brisance is a property of only moderate value, since any force applied to disintegrate a heterogeneous solid should be applied to its weaker portion, the ice bond, rather than to crushing the solid boulders.

Despite the fact that high-velocity explosives produce a narrower cone, minimizing the danger of cutting off adjacent unexploded charges, their overall action is rather poor, since most of the energy is absorbed by shattering of boulders.

By using medium-velocity, medium-strength explosives and frozen stemming, the powder ratio could be brought to a minimum value of 3.1 lb/yd^3 of permafrost (Table I).



a. before blast.

b. after blast.

Figure 4. Longitudinal cross section of the tunnel face. Note overbreak on the floor.

This may be lowered still more by applying millisecond delays and refining the drilling pattern.

There are indications that initial shots in the round cut off parts of explosive charges in the subsequent holes. This may be one explanation of the high powder consumption during the 1959 operation, and at the beginning of the 1960 season.

Two experimental rounds were fired with high-strength, high-velocity explosives in the burn (central holes), and medium-velocity powders in the remainder of the drill holes (Fig. 3; 4a, b). Despite some excessive spread of the muck pile, satisfactory results were obtained.

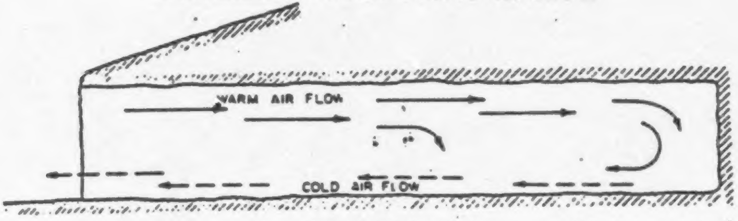
The data summarized in Table I indicate some success in the improved application of explosives. Despite the fact that explosives represent the cheapest source of energy, excessive use of them would present a problem in excavation costs, especially under arctic conditions where transportation expense may become prohibitive. In addition, the increased drilling time would impose great expenses.

Ventilation and air flow

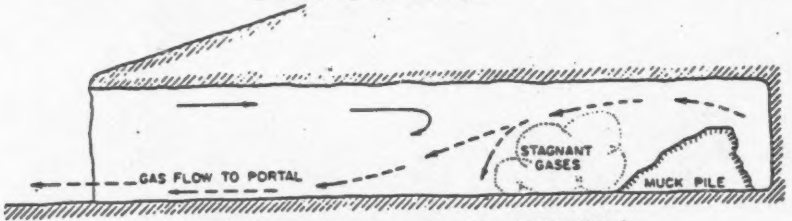
The natural air flow in the tunnel during the summer is fairly simple to demonstrate (Fig. 5a); warmer outside air enters the tunnel through the portal and moves slowly inward depositing hoarfrost on the walls. Dry, cold, dense air moves out along the floor of the tunnel forming a layer only 1.5 ft high. The layer is easily recognizable by the absence of hoarfrost on the lower part of the tunnel wall.

An explosion at the end of the tunnel instantly liberates a large amount of hot fumes and offsets the natural circulation, forming dangerous stagnant fume pockets (Fig. 5b). Forced ventilation applied at two points to act parallel with natural convection currents was most effective in eliminating them (Fig. 5c). With this arrangement, ventilation time was cut down to 15 min, as compared with as long as 65 min using reversed fans.

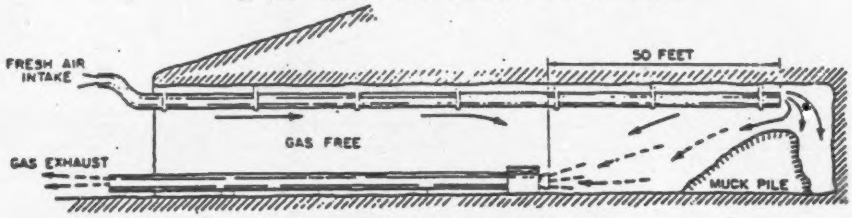
The effective fan capacity was estimated at 1000 ft^3/min in both directions. This figure is based on one 7.5 hp exhaust fan, 3500 ft^3/min, at 4 in. water pressure differential, connected with a flexible canvas ventilation pipe 24 in. in diam and a 3.5 hp fan of correspondingly lower capacity on a rigid ventilation pipe carrying fresh air in.



a. NATURAL CIRCULATION



b. GAS FLOW AFTER BLAST. (NO VENTILATION)



c. RECOMMENDED VENTILATION SET-UP

Figure 5. Air circulation patterns.

(The difference between the estimated and the nominal fan capacity was due to the abnormally high line loss along the 550 ft, due to hoarfrost forming in the line.)

Miscellaneous uses of freezing

In the usual mining procedure, there is always some effort needed to lay rails and switches on a flat stable bed. Additional work for maintenance of the rail system is always required. A permanently frozen environment reduces that to a minimum. Railwork laid out on a flat bed of comparatively fine material becomes permanently bonded to the bed and is very stable if some moisture is added after the layout is completed. The need for ties is minimized and maintenance is reduced to a negligible amount. It appears that the useful life of rail systems in permafrost environments is very long. Similar uses of the freezing environment were made in many cases where backfill was needed to prop up equipment, make foundations for machines, etc.

DESCRIPTION OF THE TUNNEL

The result of the two seasons of excavating is a 605 ft tunnel with three rooms excavated off the main drift (Fig. 6)*. The first room, approximately 10 x 10 x 12 ft, is on the left at the end of a 10 ft long adit 295 ft from the portal, and is separated from the main tunnel with a double bulkhead. The room will be used for long-range observations of the properties of permafrost. It is equipped with two mutually perpendicular semi-profiles of thermocouples and power units which provide a heat source. (Results will be published in a separate report.)

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* For 1959 work, see Abel (1960).

Figure 7. Furniture and seismograph foundation made from permacrete.

Figure 8. Permacrete column supporting loose slab in the roof. Note also hoarfrost formation. Permafrost tunnel, turnout to side room at 290 ft.

by the surface produced a thin skin of frozen silt which is much more resistant and more efficient in binding loose rocks in the roof than is clean ice. Some skill was needed in the application of warm water. Repeated application in one area resulted in dangerous, although temporary, weakening of the surface because of the rapid addition of heat.

The method of application — spraying or coating with a mixture — was unimportant. The result — a firm skin on the wall and roof holding any previously loose material in place — was quite spectacular.

Roof strength was studied also by setting off charges of dynamite on the floor and observing the slabbing effect. A tunnel segment of a given length was selected and every protruding boulder was marked with spray paint. Then a 2-lb charge of 60% dynamite was set off on the floor (6 ft under the roof). The experiment was performed with both a 6 ft and a 10 ft span. The shock invariably knocked out rocks from untreated sections, but failed to affect roof segments coated with a thin layer of ice or clay and rock flour slurry.

Another direct mining application of permacrete was roof support by permacrete columns of large slabs which had become dangerously "drummy". In one case, a 9 ft column made of four pre-cast elements was utilized (Fig. 8). One worker installed such a column in 6 hr including filling the molds (freezing time not included). The column arrested the exfoliation of the roof. The unsafe part of the roof came to equilibrium and, despite repeated blasting in the vicinity, both column and roof were stable.

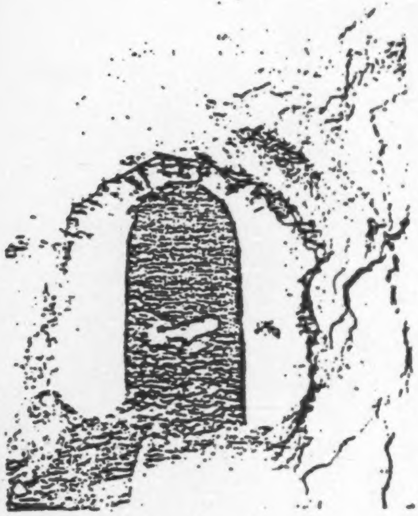

Figure 9. Masonry permacrete arch, 560 ft from portal.

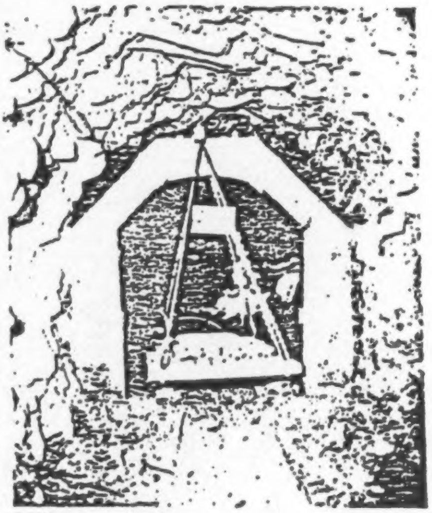

Figure 10. Loaded pre-cast permacrete arch, 620 ft from portal.

Floors. To obtain flat usable floors, an extremely simple method was successfully employed. A 6-in. layer of fine-crushed rock (pea gravel) was spread, filling depressions and irregularities in the natural permafrost floor. It was allowed to cool down to -5C. A mixture of water and snow was then poured over it. After solidification, this floor withstood 250 psi rolling wheel load. It was especially resistant, even to sharp blows from picks or sledge hammers and any damage could be very easily repaired with sand and water. Moisture content was held at approximately 35% of saturation value. The rough texture of the floor surface was found to be advantageous, and no attempt was made to apply a smooth finish.

Bricks and arches. Masonry work, such as laying permacrete brick, was tried in the tunnel. It was concluded that masonry with permacrete does not differ much from its "warm" counterpart. However, it was found that the solidification time for small pieces of permacrete is much shorter than for small pieces of concrete (3 yd^3 froze in 30 hr).

Two types of permacrete arches, masonry (Fig. 9) and pre-cast (Fig. 10), were erected for investigation of: (1) applicability; (2) labor involved; and (3) creep investigation.

The conclusion from this investigation is that permacrete arches are practical in this environment and that the actual amount of labor required in making them is less than is necessary in concrete work.

Beam experiments. Since it is suspected that an unfavorable amount of creep exists in permacrete beams, three long-range tests have been set up (Fig. 11). Two of the beams have a cross-section of 10 x 10 in., are simply supported, and have a span of 8 ft. The other is a cantilever with the same cross-section and an unsupported length of 8 ft. All three beams are subjected to dead load only. Deflection can be determined by comparing reference points at 1-ft intervals to an independent straight line. Preliminary data show no unfavorable creep.

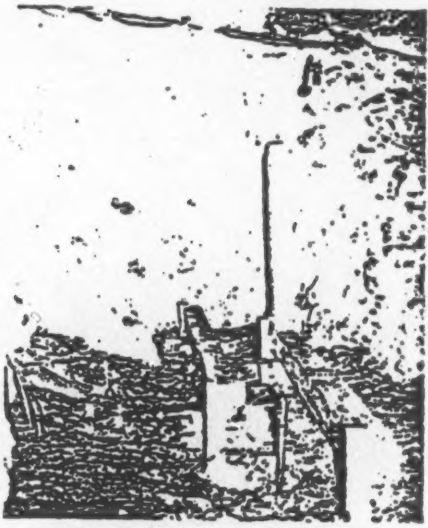

Figure 11. Permacrete beam experiments.

Table II. Permacrete mixtures.
(In all cases water-saturated)

Grain size (mm)	Mortar	Brick	Column	Floor	Poured cast
20	-	-	0.7	-	-
10	-	0.6	-	-	-
5	-	-	-	1.0	0.2
1	0.4	-	-	-	0.1
0.4 (40 mesh)	0.25	0.2	0.15	-	0.2
0.08 (200 mesh)	0.1	0.2	0.15	-	0.5
0.01	0.1	-	-	-	-
Clay	0.15	-	-	-	-
Final porosity	20%	22%	27%	40%	31%

Optimum composition

Optimum mixtures for various purposes were obtained by a series of trials. The results are summarized in Table II. The data in Table II are merely preliminary information. There is an obvious need to investigate the problem of optimum mixtures for any specific use of permacrete. However, some general principles may be stated.

In the case of an aggregate of uniform spherical particles, the theoretically obtainable maximum bulk density is 74.05% of the density of the particles. The addition of another size of sphere, just fitting into the pores, will increase maximum density to approximately 80%. Further introduction of successively smaller spherical particles will gradually decrease the pore space and increase the bulk density of the mixture. However, the greatest strength is not necessarily related to maximum density. The addition of increasingly fine material causes a greater dispersion of water droplets, and thus the freezing temperature of the mixture is lowered. That means that a mixture containing a great amount of fine material would have a great amount of unfrozen water at a given temperature. Therefore, particles 1μ and smaller should be avoided in any mixture.

An aggregate of angular particles always has a wider range of void sizes than an aggregate of spheres. Therefore, mixtures of angular material require a more finely grated filter.

The strength of a specimen seems to be affected also by the ratio of the size of the coarsest fraction to the cross-section of the specimen, which determines the upper limit of the particle size.

In addition to recommended compositions given in Table II, the following set of general rules was established.

1. Complete saturation and especially supersaturation of the mixture produces weakening of the frozen material and increases brittleness (see Appendix A). A saturation (thawed) between 90 and 95% gives best results.

2. Compressive strength is highest when the coarse fraction is high. The composition of the pore filler is irrelevant.

3. Greatest tensile strength is obtained when the finest fraction is smaller than 0.01 mm and the ratio of coarsest to finest is low (exact values of that ratio have not yet been determined). There is a definite need for further investigations which are presently underway.

DISCUSSION

Tunneling in cold permafrost is very similar to operations in competent rock in temperate climate. The disadvantages, such as the need for antifreeze solutions and for fully winterized equipment together with other smaller disadvantages, are offset by the greater efficiency of explosives and the ease of use of artificial frozen soil material as an aid in mining.

The best method for tunneling in permafrost is a cyclic system consisting of mucking, drilling, blasting, and ventilating. The best drill pattern is a burn cut pattern drilled to two-thirds the width of the tunnel.

Medium-strength, medium-velocity explosives with a delayed blast and a 0.5 sec interval are recommended. Nothing can be said about millisecond delay caps, pending further investigation. Charging the burn (central holes) with higher velocity explosives provides advantages, since the material in the face shattered by the sharp impact of the burn is removed and placed in a compact pile with a good fragmentation.

The best stemming is a wet clay-silt mixture which fills the drill holes fully and is allowed to freeze back completely, sealing the entire hole.

The cost of mining in permafrost is not higher than in mining warm rock. An estimate of the cost for the 1960 operation is given below:

Contract personnel wages (5 persons)	$15,000.00
Army personnel (9 at $100.00/month)	8,100.00
Camp costs (14 men at $5.00/day)	6,300.00
Amortization (1/5 $60,000.00)	12,000.00
Explosives	2,200.00
Fuel	800.00
	$44,400.00

Estimating that the work done in 1960 is equivalent to 620 ft, the cost of 1 linear ft is $71.16 for a 6 x 7 cross-section, or, considering that the total volume of material removed was 1000 yd^3, the cost of removal was $44.40/yd^3. A comparable tunnel in the continental United States would cost approximately $85.00/linear ft. Most of the lower cost is due to lower labor costs. It is apparent that if the miners were paid an average U. S. hourly pay, permafrost mining costs would be only slightly lower.

It is emphasized that maximum productivity per man or machine could be increased further. Mucking could be as high as 50 cars/day (10-hr shift) for a crew of five (average was 27 cars/shift). Drilling (one drill, two men, 10 hr) could exceed 220 ft, but average productivity was around 150 ft. The above maxima would be applicable in mining in permafrost where staggered stages of production could be applied successfully.

Subsurface shelters, storage areas, and military installations could be excavated in permafrost with certain advantages over warm rock. Beside the advantage of low temperature for storage, there is the ease of construction of foundations, partitions, etc. Freezing temperatures can be used in a variety of subsurface jobs, such as laying rails, stabilizing walls and roofs, shoring up ceilings, and repairing fractured pillars. Permafrost resistance to explosions is similar to that of competent rock and it does not deform with time as do snow and ice. Permafrost, and permacrete, can withstand flash heating such as occurs during black powder explosions or rocket firings.

It has been demonstrated that permacrete may be successfully used as a substitute for concrete in many fields of construction. Small-scale construction is most successful for any such subsurface work in permafrost where preservation of cold is anticipated. There is not much difference between manufacturing pre-cast permacrete and pre-cast concrete. The difference is that permacrete does not require portland cement. Permacrete has a comparatively short "curing time", freezing time only, and can be remolded and reused at any time. Labor and machinery are utilized in the same way as in concrete work.

The use of permacrete in tunneling in permafrost is most advantageous when it is applied to roof and wall support by spraying and plastering with unfrozen material. Utility rooms, research laboratories, and storage rooms could be constructed by plastering rough excavations in permafrost with a saturated mixture of relatively fine material. Permacrete may be used at the surface, as well as underground for foundations and fortifications in permafrost regions.

In summer, permafrost tunnels can be ventilated without refrigeration only in cold permafrost. Permafrost whose temperature is close to the melting point would need refrigerated air for ventilation unless operations are limited to the winter season.

RECOMMENDATIONS

Since tunneling has proven to be possible and feasible for military installations in cold permafrost, it should be investigated for warm permafrost (only a few degrees below freezing) in a region such as Alaska or northern Canada.

Observations of long spans in permafrost should be continued. Natural arching and roof failures should be produced and measured.

Investigation of permacrete should be continued in the laboratory and in the field, based upon the knowledge already gained in concrete research.

Temperature investigations in the tunnel may reveal data on thermal history from the start of the present geological period until the present time. It is recommended that thermal observations be continued and correlated to glaciological data.

A small camp should be erected in the large room in the tunnel to demonstrate its feasibility as a shelter.

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APPENDIX A.

4. A thin plaster-like paste of silt (rock flour), clay, and water was troweled on the surface and allowed to freeze to the permafrost. (A very time-consuming process).

Test no.	Diam (mm)	Test no.	Diam (mm)
1	3.	7	3.
2	2.5	8	2.5
3	2.5	9	2
4	2.5	10	2.5
5	3.		
6	3.		Avg 2.65

Remarks: Every test showed clean, conical holes, only very little peripheral fracturing.

Conclusion

Coating of the tunnel surface with a clayey water solution improves the skin condition and reduces the danger of rock fall. Addition of clay and rock flour to water improves skin hardness.

Brittleness of permacrete

It was noticed on several occasions that some permacrete mixtures displayed an undesirable amount of brittleness. The following test was devised to formulate ideas as to the influence of composition on the brittleness of the permacrete.

The material was cast into blocks 10 x 10 x 30 in. and dropped lengthwise onto a mine rail. The height of drop was increased until damage occurred. The maximum height of drop at which failure occurred was considered the reciprocal relative brittleness.

Composition	Height of failure (ft)
1. Till, remolded	
Saturated	3
Supersaturated	2.5
2. Pea gravel	
Saturated	2.6
60% of saturation	1.6
3. 50% pea gravel 50% silt	
Saturated	3.2
Supersaturated	1.6
4. Varved clay from shear moraine	
40% moisture content (Specimen bends!)	6 and more
5. 40% pea gravel 30% silt 20% 1 in. pebble 10% clay	
Saturated	3.7
6. Poured clay	
70% moisture (ice lenses)	2
7. 20% pea gravel 20% 1 in. pebble 30% rock flour 20% sand 10% clay	
20% moisture	2.6
Saturated	3.9
10% moisture	2.4

Conclusion

Clay as an additive decreased brittleness, but a predominance of clay in the mixture produces a considerable increase in plasticity in the frozen state. The best mixtures seem to be heterogeneous in size with only 10% clay. The mixture should never exceed saturation.

APPENDIX B

Manufacturers' Literature

Specification

Dintheader (STANDARD) WITH MK IIA ENGINES

OVERALL DIMENSIONS

Length	5 740 mm	(18'–10")
Height	1 280 mm	(4'–2½")
Width – maximum	1 715 mm	(5'–7½")
Width – minimum (without bollards)	1 475 mm	(4'–10")

TOTAL WEIGHT OF MACHINE	16 750 kg	(16.5 tons)

CUTTING ASSEMBLY

Standard Cutting Chain	Dosco to suit customers requirements	
Width of Cutting Chain	917 mm	(36.1/8")
Speed of Cutting Chain	0.75 – 1.82 m/s	(148–385 ft/min.)
Peripheral Pick Speed	1.27 – 3.05 m/s	(250–600 ft/min.)

FORCE AVAILABLE AT CUTTING HEAD

Lifting	200 kN max.	(20 tons f. max.)
Max. Chain Pull	117 kN @ 1.27 m/s	(11.7 tons f. @ 250 ft/min.)
Sumping thrust available at cutting head	90 kN @ 70 bar	(9 tons at 1 000 lbf/in²)

Type of cutter picks – (Different types available. Recommendations depend upon strata type)

LOADING ASSEMBLY

Type of Conveyor	Scraper	
Cross Sectional Area	0.123 m²	(1.32 sq.ft.)
Speed of scraper (normal)	0.84 m/s	(165 ft/min.)
Speed of scraper (with cross conveyor)	1.07 m/s	(210 ft/min.)
*Max. loading vol. assuming full trough (normal)	372 m³/h	(486 cu. yds/hr.)
*Max. loading vol. assuming full trough (with cross conveyor)	470 m³/h	(615 cu. yds/hr.)
Fluid H.P. delivered to motor	10.5 kW	(14 hp)

*Factor must be applied for loose material (e.g. 0.66 R.O.M. Coal, 1.5 for Gypsum).

CRAWLER ASSEMBLY

Details of chain – 56 links at pitch of	89 mm	(3½")
Length of track on floor	1 473 mm	(4'–10")
Width of track	456 mm	(14")
Ground Pressure	0.149 MN/m²	(21.6 lbf/in²)
Track Centres	940 mm	(3'–1")
Speed – working	0 – 0.03 m/s	(0–6½ ft/min.)
Speed – maximum tramming	0.08–0.10 or 0.14 m/s	(16–19 or 28 ft/min.)
Type of motor – Hydrostatic Transmissions	9 kW	(12 hp)

HYDRAULIC EQUIPMENT

Number of pumps	2 tandem	
Total capacity of pumps	3.6 l/s	(48 galls/min.)
Number of hydraulic motors	(4) including conveyor and track motors	
Oil capacity	364 litres	(80 galls.)
Working pressures of conveyors	140 bar	(2 000 lbf/in^2)
Recommended hydraulic fluid	Aquacent 'Light' or 'Heavy' F.R.F.s or Walkers P.W.L.C. mineral oil.	

ELECTRICAL EQUIPMENT

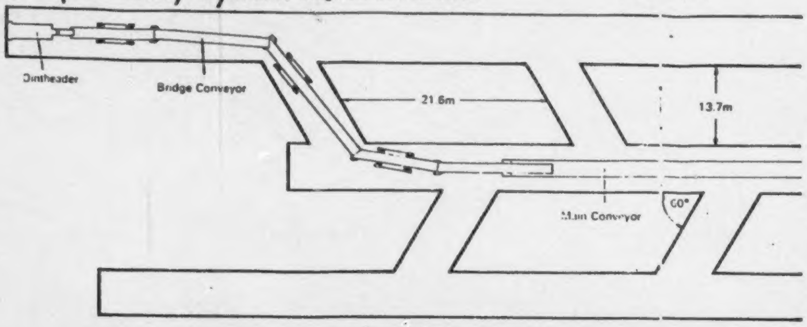
Hydraulic pump motor (water cooled)	90 kW	(120 h.p.)
Total electrical power	90 kW	(120 h.p.)
Voltage	550/1100 V or 400/440 V	
Frequency	50 or 60 Hz	
Control Panel	Baldwin & Francis or to suit customer	
Oil level switch	Mobrey Magnetic type	
Trailing cable	Type 7 – 50 mm^2 (1 Pilot) (1 Earth) (3 Power Cores)	
Headlamp (1 per m/c)	Westair Dynamics 24 V. 70W. or to suit customer	
Pump motor cable	Type 7 – 50 mm^2	
Lighting and pilot cable	Type 62 – 4 mm^2	
Hydraulic oil thermostat	Maclaren or Samford Type 2/85° C.	(35/185° F.)

WATER CIRCUIT (Standard)

Rate of flow	0.26 – 0.38 l/s	(3½–5 galls/min.)
Working pressure	12 bar	(180 lbf/in^2)

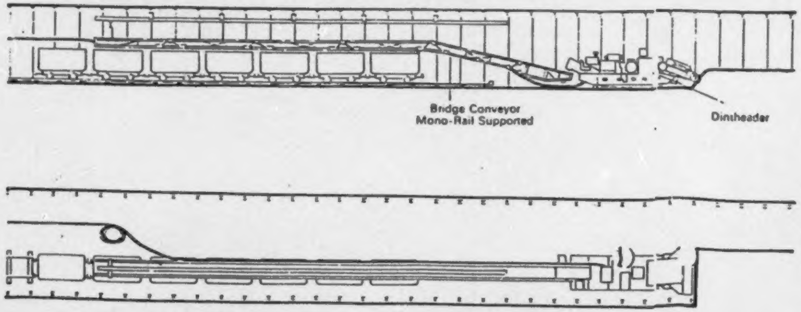
ISSUE 1/79

Multiple Entry System Using a Standard Dintheader

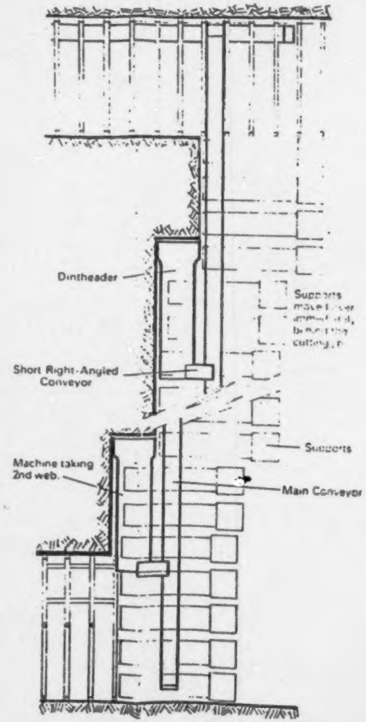

Dintheader
Bridge Conveyor
21.6m
13.7m
Main Conveyor
60°

A Three Heading System.

Roadway Dinting (Floor Grading) Using a Standard Dintheader


Bridge Conveyor
Mono-Rail Supported
Dintheader

Shortwall System Using a Standard Dintheader


Dintheader
Supports moved over immediately, behind the cutting m/c
Short Right-Angled Conveyor
Supports
Machine taking 2nd web.
Main Conveyor

THE DOSCO CORPORATION
Western Division

6733 E. 47th ave. Dr.
Suite H
Denver
Colorado 80216

303-321-5597
Telex 45-4369

DN : ups

September, 9th, 1981.

Mr. David Krebs,
Senior Project Engineer,
ERTEC Rocky Mountain,
1746 Cole Blvd.,
Golden,
Co. 80401.

Dear Mr. Krebs,

In response to our phone conversation of this morning, I am enclosing information on the Dosco Dintheader for the Alaskan Coal project you are studying.

The Dintheader is a small, simple, yet very robust machine capable of cutting rock up to 10,000 p.s.i. and coal at a rate of up to 4 TPM. The Dintheader would be an excellent tool on this job because of its simple design, 14 tons, one 145 H.P. motor to run the hydraulic system which runs the cutter jib, conveyor, and tram, and that is just about it. Dust collection hoods are available for the Dinter if required, however normally an exhaust fan and tube is used.

The cost of a Dintheader, F.O.B. U.K. port for the end of 1981, is approximately $446,000. However, there are two units available within the States at a much lower cost.

I am also enclosing brochures on our other equipment for your information and if I can be of any further assistance please call at any time.

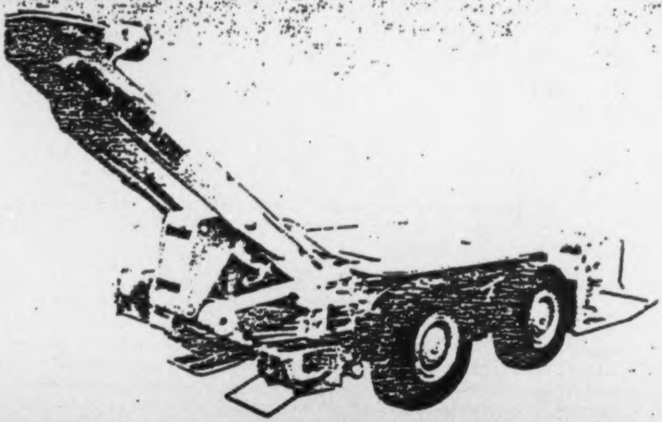
Best regards,

DAVID M. NEIL
Manager (Western Division)

ENCLOSURES

LONG-AIRDOX
LRB-15A ROOF BOLTER

YOU CAN SET MORE BOLTS WITH THIS MACHINE



BECAUSE

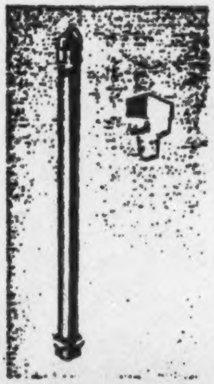
LONG-AIRDOX BUILT INTO IT AN UNMATCHED COMBINATION OF . . .

1. Maneuverability . . . . Get in, fast; get out, fast!
2. Thrust . . . . }
3. Rotation . . . . } Secure the roof, fast!

. . . . and produced the model LRB-15A Roof Bolter which has no peer for roof drilling and setting roof bolts in underground mines.

BJW Bulletin 6-475-1

LONG-AIRDOX BITS AND RODS . . .
. . . MEAN FASTER ROOF DRILLING



Give your roof bolter the benefit of smoother drilling with Long-Airdox bits and rods, contoured for fast, smooth drilling and collection of cuttings, and engineered to match the performance of Long-Airdox roof bolters.

Long-Airdox bits are produced by carbide tool specialists for fastest penetration, longest wear and effective dust collection.

The rods support the bits with the strength required to transmit the thrust and torque for unmatched penetration . . . and provide the unobstructed flow of cuttings.

FIELD SALES OFFICES & WAREHOUSES

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Benton, Illinois 62812
Box 479
(612) 438-3821

St. Clairsville, Ohio 43950
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(614) 695-1790

Finleyville, Pennsylvania 15332
R. D. #2
(412) 348-7143

Robinson Creek, Kentucky 41560
(606) 639-4493

Camden-on-Gauley, West Virginia 26208
(304) 226-3571

Harper, West Virginia 25851
(304) 253-4812

Price, Utah 84501
(801) 637-3236

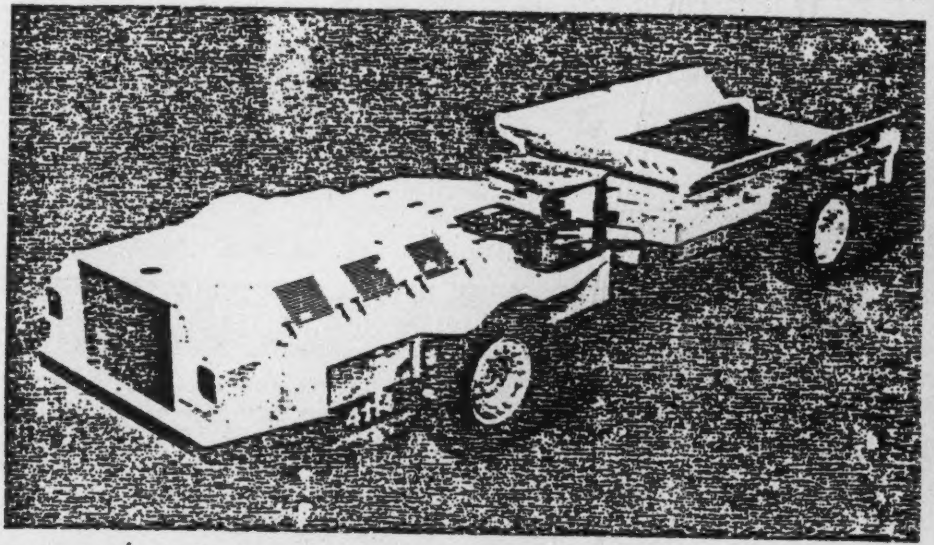
LONG-AIRDOX CO.

a division of THE MARMON GROUP, Inc.
Box 331, Oak Hill, West Virginia 25901

BJW Bulletin 6-475-1

SPECIALISTS IN UNDERGROUND MINING, HAULAGE, VENTILATION SYSTEMS **JEFFREY**

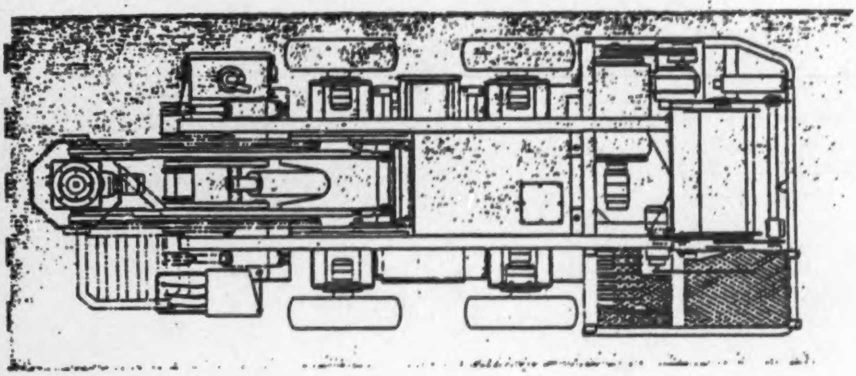
4114 Diesel RAMCAR® Haulage Vehicle



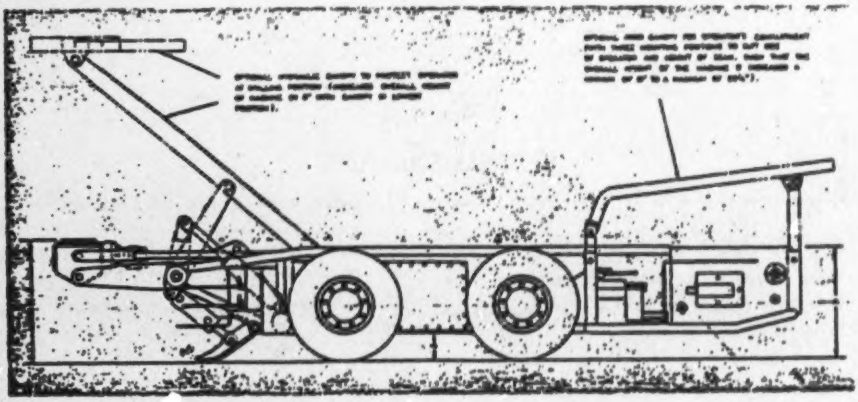
Built to MSHA requirements for underground coal/hard rock mining

- 14 ton (12.7 t) rated capacity for coal; 18 ton (16.3 t) maximum load limit
- 17" to 21" (432 mm to 533 mm) ground clearance for bad bottoms
- 4-wheel chain drive permits true tracking, eliminates axle-mounted gearing and differential bulge
- Cantilevered canopy provides swing-away access to sound-insulated operator compartment, improves visibility
- Axial oscillation pivot keeps all four wheels on the ground in turns from steep grades to level
- 90 gallon (341 liter) water tank sufficient for two full shifts of exhaust scrubbing
- Dirt locked out of 43 gallon (163 liter) pressurized hydraulic reservoir
- Noise level reduced by fully enclosed engine compartment
- Designed for tight turns: inside circle radius 10'9" (3.28 m), outside 22'3" (6.78 m)
- Flat, sealed tractor bottom keeps dirt and mud out of engine compartment
- 8-hour changeout Schedule 31 (Title 30, Part 36) Diesel Power Pack

ARRANGEMENT OF THE LRB-15A ROOF BOLTER



Overall height (A)	26"	28½"	30½"	32½"
Ground clearance (B)	5½"	8"	10"	12"
Drill head height (C):				
On level ground	10"	12½"	14½"	16½"
Minimum	10"	12½"	14½"	16½"
Maximum	70"	72½"	74½"	76½"
Drill boom lift	5'-0"	5'-0"	5'-0"	5'-0"
Overall length	14'-9½"	14'-9½"	14'-9½"	14'-9½"
Overall width	6'-0"	6'-0"	6'-0"	6'-0"
Tire size	7.00 x 12	7.00 x 12	7.00 x 12	7.00 x 12
Wheelbase	3'-6"	3'-6"	3'-6"	3'-6"



FEATURES OF THE LRB-15A ROOF BOLTER

GENERAL

Drilling:	
Speed	variable, 0 to 550 rpm
Torque	variable, 0 to 247 ft. lbs.
Drill boom:	
Lift	hydraulic
Stabilizer	hydraulic, centerpoint
Thrust	up to 8000# at 2000 psi
Speed (feed)	up to 27 fpm
Tramming:	
Type	hydraulic, 4 wheel
Speed	variable, 0 to 2½ mph
Steering	crawler style, rotates about its own center of gravity
Controls	hydraulic, push pull, spool valve

Panic bar: lever operated panic bar removes power from electric motor and brakes are set.

Electric motor (1):	
AC (1800 rpm, continuous)	40 hp
DC (1800 rpm, continuous)	20 hp
Trailing cable recommendation:	
AC	3 cond. #6 type GGC round
DC	3 cond. #6 type W round
Dust collector	through-the-steel, cyclone and filter bag collector
Hydraulic oil tank	55 gals.
Brakes	"dead-man" type, spring set, hydraulic release
Cable reel	horizontal axis, hydraulic
Weight of machine	7500 lbs.

Permissibility: MESA approval of the electrical system, the dust control system, safety features, etc.

OPTIONAL EQUIPMENT

Fire suppression system (one canister, dry type).

Rigid canopy for operators compartment.

Hydraulic power take-off (for operating hydraulic tools, etc.).

Hydraulic clutch to disengage dust collector vacuum pump when tramming, etc.

Hydraulic canopy to protect operator at drilling position.

SPECIFICATIONS: Jeffrey®4114 Diesel RAMCAR®Haulage Vehicle

Length . . . A . . . 33'10" (10.31 m)
Width . . . B . . . 11'3" (3.43 m)

		Standard	Optional	Optional	Optional
Tires		17.5 x 25	18L x 26	18.0 x 25	20.5 x 25
Width over tires	C	10'10" (3.3 m)	11'0" (3.35 m)	10'10" (3.3 m)	11'6" (3.51 m)
Overall height	D	61" (1 549 mm)	58" (1 473 mm)	65" (1 651 mm)	65" (1 651 mm)
Height over canopy (min)	E	73" (1 854 mm)	70" (1 778 mm)	77" (1 956 mm)	77" (1 956 mm)
Ground clearance (min)	F	17" (432 mm)	14" (356 mm)	21" (533 mm)	21" (533 mm)
Ground clearance (axle)	G	21" (533 mm)	18" (457 mm)	25" (635 mm)	25" (635 mm)
Approach angle					
Tractor		14°	11°	16°	16°
Trailer		11°	9°	13°	13°
Turning circle					
Inside	H	10'9" (3.28 m)	10'8" (3.25 m)	10'9" (3.28 m)	10'6" (3.20 m)
Outside	I	22'3" (6.78 m)	22'3" (6.78 m)	22'3" (6.78 m)	22'4.5" (6.82 m)

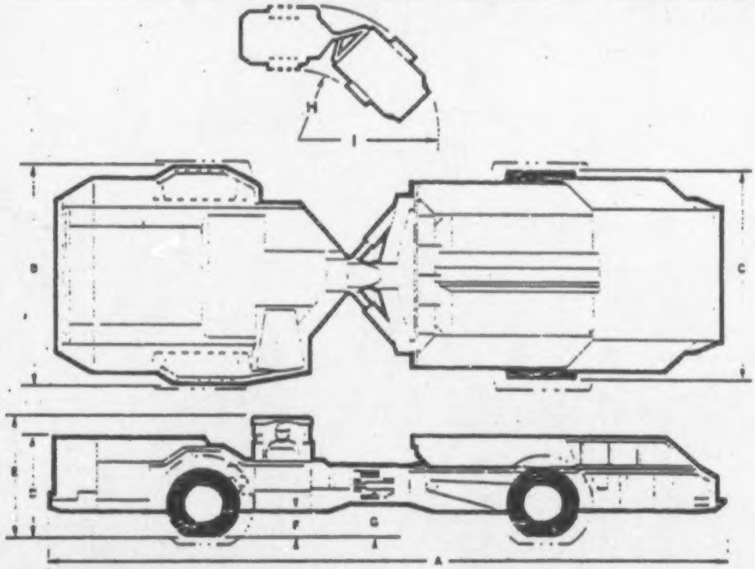
Weight (Mass) . . . 42 000 lbs (19 051 kg)
Capacity . . . 14 tons (12.7 t) nominal
18 tons (16.3 t) maximum

Discharge time	15 seconds
Maximum speed	6 mph (9.65 km/h)
Articulated steering	110°
Fuel tank	40 gal (151 liter)
Scrubber water tank	90 gal (341 liter)
Engine	6-cylinder, 4-cycle Caterpillar diesel 150 hp (112 kW) @ 2200 rpm
Transmission	Three speeds forward and reverse, power shift with torque converter
Gear ratio	
Transmission	1st 4.3:1, 2nd 2.3:1, 3rd 1.3:1
Final drive	33.2:1
Starting system	Compressed air
Exhaust scrubber	Cyclonic water type
Brakes	4-wheel inboard power disc

Optional equipment

Fire extinguisher system
Side dumpers for trailer
No-spin differentials
Screen extensions
2-post cantilever canopy

NOTE: We reserve the right to change specifications appearing in this bulletin without incurring any obligation for equipment previously or subsequently sold.

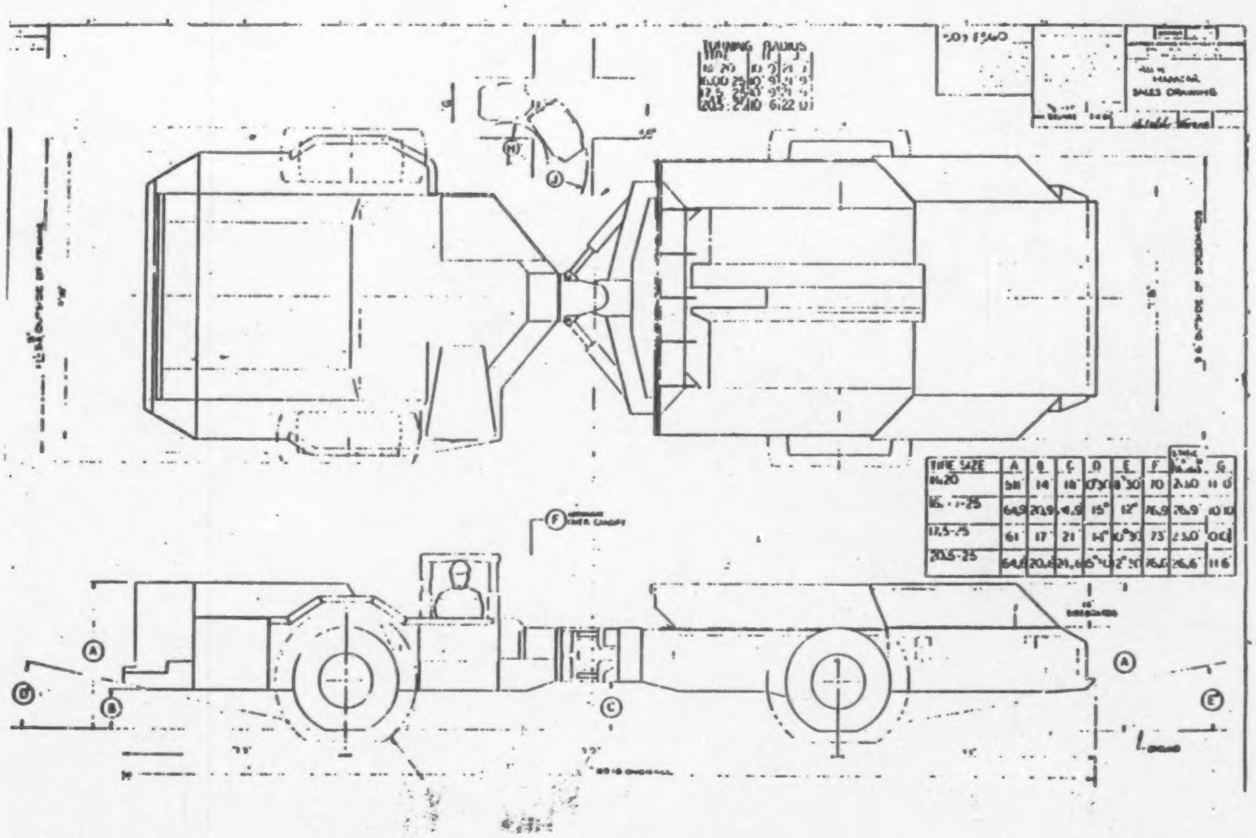


JEFFREY DRESSER

JEFFREY MINING MACHINERY DIVISION
DRESSER INDUSTRIES, INC.

P.O. BOX 1879 COLUMBUS, OHIO 43216 U.S.A.
Phone 614 267-3123

Bulletin No. [illegible]


TURNING RADIUS
SALES DRAWING
TIRE SIZE
A
B
C
D
E
F
G
14-20
16.00-25
17.5-25
20.5-25
A
B
C
D
E
F
G

Controls - continued

This is operated by the driver's left hand and the main steering control lever is operated with his right hand.

The throttle and service brakes are operated by pedals which are arranged with the standard automobile layout.

Two simple mechanical interlocks sequence the following functions:

1. The engine can not be started unless the shift lever is in the neutral position.
2. The manual override of the automatic shut-down device can only be operated with the parking brake in the applied position.

ain Frame

The main chassis is constructed in 1" thick plate with a 1/2" wrap around amper plate protecting the engine from a rib impact. Easily removable cover lates keep the engine compartment clean.

riving Position

The lateral driving position situated between the wheels, together with the long wheelbase of the RAMCAR, provides operator comfort, convenience, and safety hich are unrivalled by any other haulage unit currently on the market. A heavy uty molded seat with good back support is mounted on a hydraulically damped load leveling suspension system.

railer

The trailer frame is ruggedly constructed in high strength steel. RAMCARS ave been operating for over eight years, and so the general principle and mechanical esign are well proven.

erformance

Low gear is designed to give the RAMCAR sufficient tractive effort to spin the wheels and provide a maximum speed of 2 mph. High gear gives the RAMCAR a aximum operating speed of 6 mph on level ground. A total hydraulic pump capacity f over 40 gpm ensures rapid unloading.

imensions and Weights

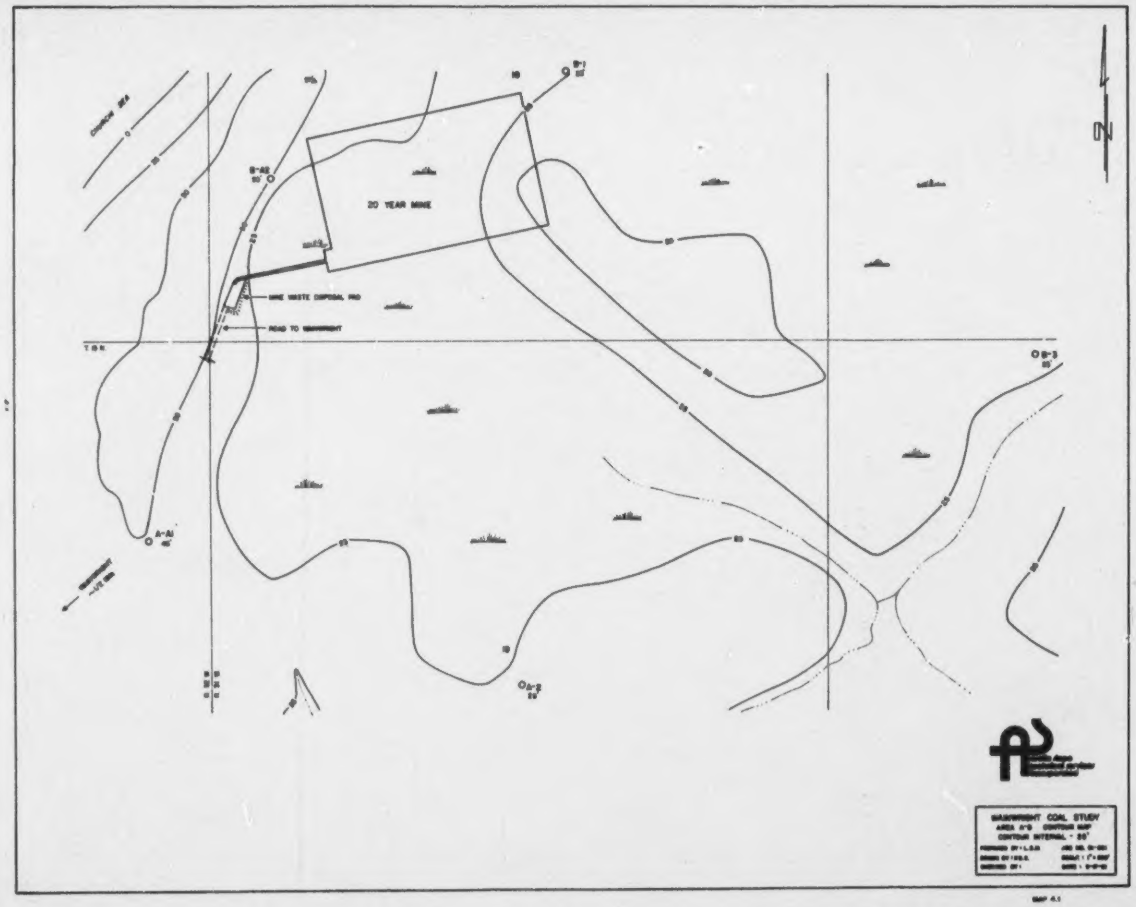
Unladen weight approximately		42,000 Lbs.
Maximum rated load		28,000 Lbs.
G.V.W.		70,000 Lbs.
Cubic Capacity	Struck Level	190 Ft.^{3}
	6" Sideboards	232 Ft.^{3}
	12" Sideboards	282 Ft.^{3}
	18" Sideboards	342 Ft.^{3}
	24" Sideboards	365 Ft.^{3}
Overall height (Frame)		59-1/2"
Trailer body height	(Struck Level)	43"
Tractor width		128"
Trailer width		128"
Overall length		33'-11"
Turning Radius	Outside	22'-
	Inside	11'-0"
Turning Articulation		±55°
Ground Clearance		16"
Height over canopy		68"

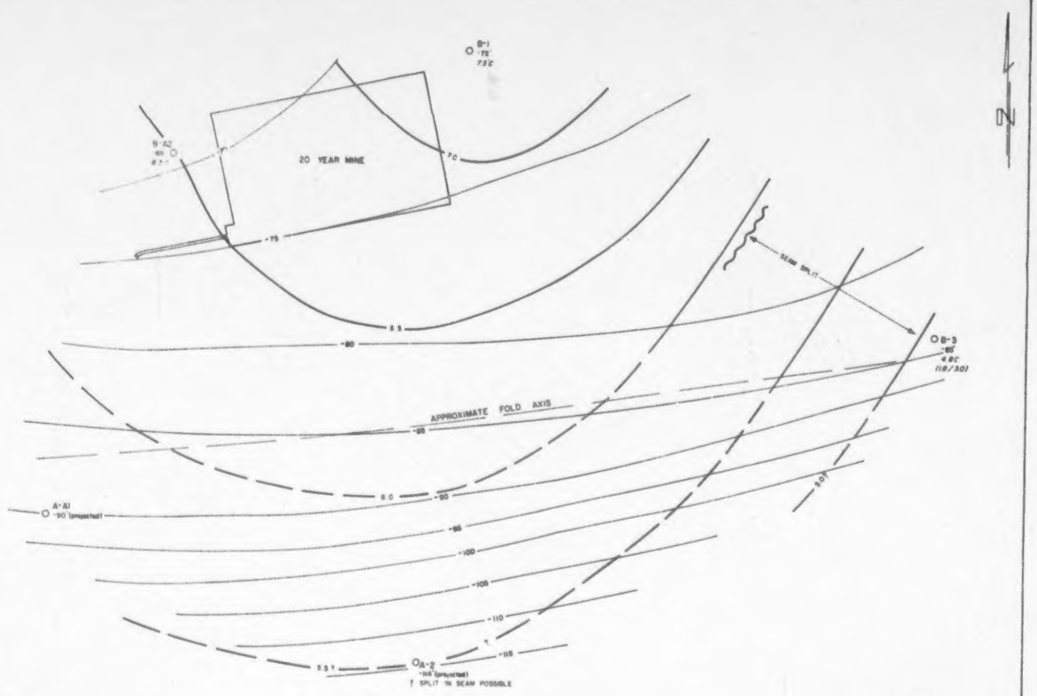
JEFFREY DRESSER

in Features of the Diesel RAMCAR

No trailing cable
No battery
Long wheelbase
Disc brakes on all wheels
High ground clearance and ramp angle
Tight turning circle (articulation)
Safe operator's location (between wheels)
Fast (15 seconds) unloading
Simple controls (no side mounted steering wheel)
No chain conveyor or conveyor drive
No complicated steering linkages
Diesel engine placed:
  1. For easy accessibility and maintenance
  2. Remote from ore for cleanliness
  3. Centrally located to protect it from rib damage
  4. Easy "Power Pack" change out
Full time 4-wheel drive
Comfort designed operator compartment
Simple hydraulics
Good operator visibility
Wide, high flotation tires
2-Post cantilever canopy

5/79


N
CHUKCHI SEA
20 YEAR MINE
MINE WASTE DISPOSAL PAD
ROAD TO WAINWRIGHT
B-A2
A-A1
B-1
B-3
A-2
T 15 N
WAINWRIGHT COAL STUDY
CONTOUR MAP
CONTOUR INTERVAL - 20'
PREPARED BY
DRAWN BY
CHECKED BY
JOB NO.
SCALE
DATE
MAP 4.1


N
B-1
-72'
7.5'C
B-A2
-69'
6.?
20 YEAR MINE
7.0
-75
8.5
-80
SEAM SPLIT
B-3
-85'
4.0C
(18/30)
APPROXIMATE FOLD AXIS
-85
6.0
-90
A-A1
-90' (projected)
-95
-100
-105
-110
-115
8.0?
9.5?
A-2
-114' (projected)
? SPLIT IN SEAM POSSIBLE

LEGEND

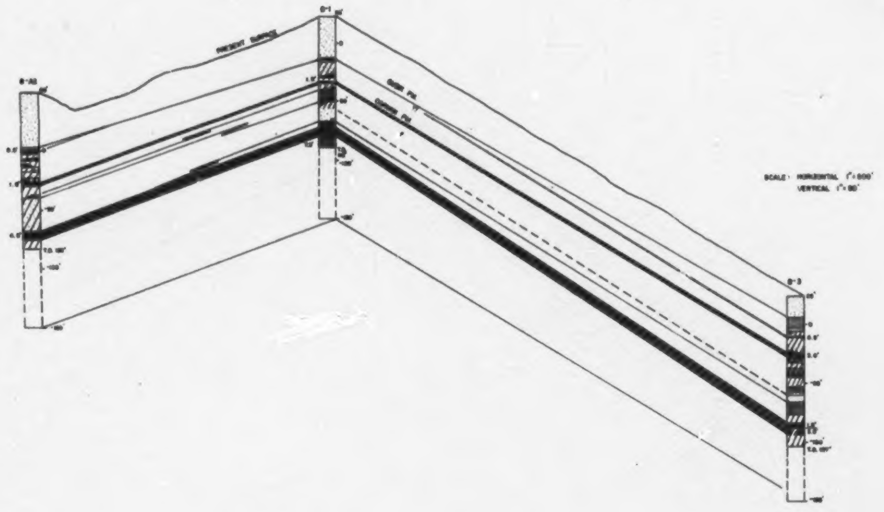
-100	ELEVATION - TOP OF LOWER COAL SEAM CONTOUR INTERVAL - 5'
6.0	COAL THICKNESS THICKNESS INTERVAL - 0.5'
○	DRILL HOLE

NOTE: LACK OF INTERCEPT DATA IN HOLES A-A1 AND A-A2 MAKES IT IMPOSSIBLE TO DETERMINE THE EXTENT OF THE PARTING SEEN IN HOLE B-3. THE APPARENT SEAM THICKENING TO THE N OR NW MAY BE THE RESULT OF THE COALESCENCE OF THE SPLIT SEAM IN B-3, AND THE SPLIT MAY WELL BE PRESENT IN THE AREA OF A-2.

WAINWRIGHT COAL STUDY
AREA A-B LOWER SEAM

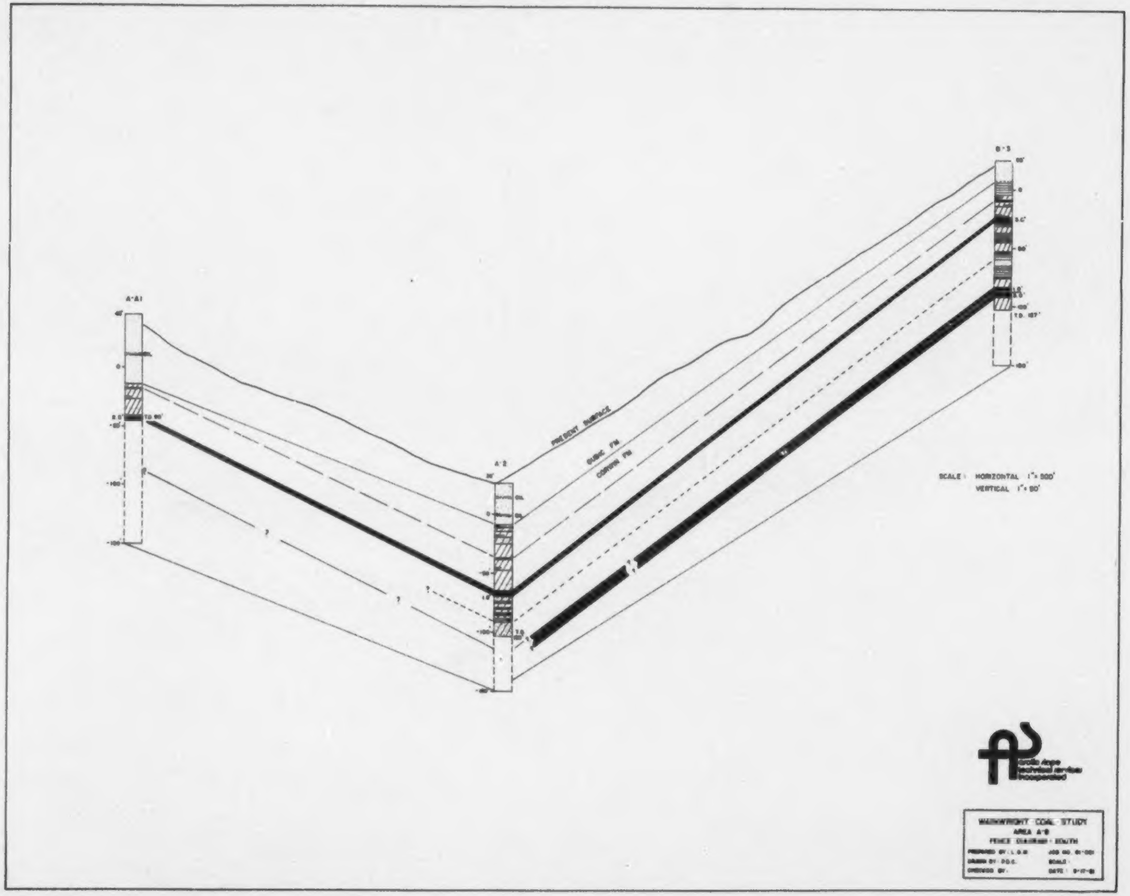
PREPARED BY: L.D.G.
DRAWN BY: D.D.C.
CHECKED BY:
JOB NO. 81-031
SCALE: 1" = 800'
DATE: 9-17-81

MAP 4.2


PRESENT SURFACE
CORWIN FM
B-1
B-3
SCALE: HORIZONTAL 1"=500'
VERTICAL 1"=50'

WAINWRIGHT COAL STUDY
AREA A-5
FENCE DIAGRAM - NORTH
PREPARED BY: L.D.H. JOB NO. 81-030
DRAWN BY: F.D.C. SCALE:
CHECKED BY: DATE: 5-18-81

MAP 4.3


A-A1
A-2
B-3
PRESENT SURFACE
GUBIK FM
CORWIN FM
T.D. 90'
T.D. 157'
?
SCALE : HORIZONTAL 1" = 500'
VERTICAL 1" = 50'
Arctic Slope Technical Services Incorporated

WAINWRIGHT COAL STUDY
AREA A-B
FENCE DIAGRAM - SOUTH
PREPARED BY: L.D.R.
JOB NO. 81-001
DRAWN BY: P.G.C.
SCALE:
CHECKED BY:
DATE: 9-17-81

MAP 4.4